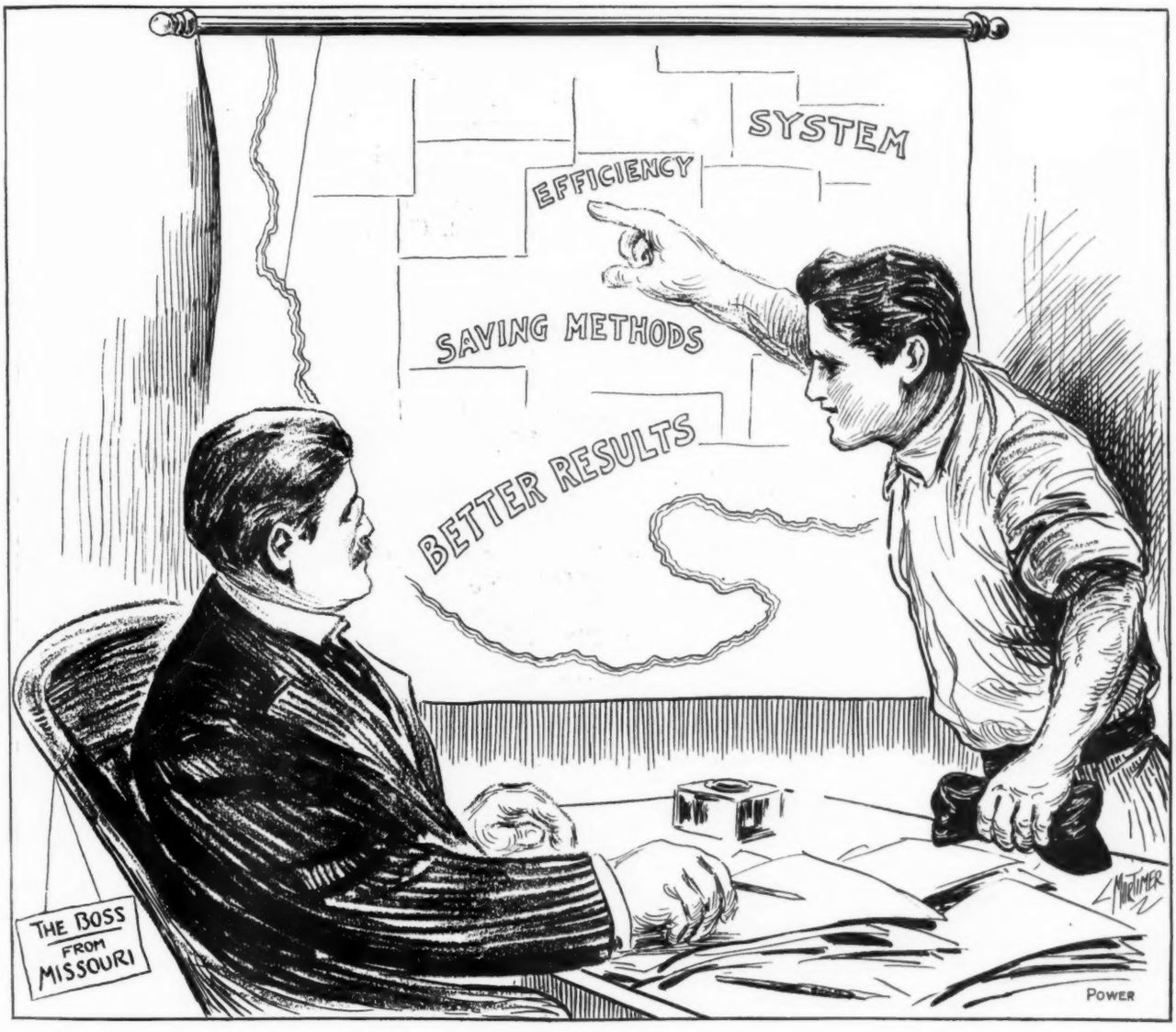
POWER

Vol. 40 NEW YORK, SEPTEMBER 8, 1914 No. 10



Virtue Is Its Own Reward

AFTER ALL, unselfishness is the best kind of selfishness. It pays. To do your best for somebody else is generally the best way to do the best for yourself.

If you can show the boss how to save money or get better results, you will have a heavier load of a pay envelope to carry home or else he is the wrong kind of a boss and you had better look out for a new one.

If you tell the boss you'll do more work if he'll give you more money, you probably won't increase your deposits in the savings bank. But if you do more work first, you have a right to demand more money and you don't have to ask for it as a favor.

Most bosses come from Missouri and if you know enough geography to show them the map, they'll come across the border.

Work and the world is with you; loaf and you're left alone. *[By Hugh Molleson Foster, New York.]*

Waterside Station, Louisville Gas & Electric Co.

By Warren O. Rogers

SYNOPSIS—The most interesting feature is the condenser pit, 53 ft. deep and 30 ft. in diameter, in which are the vertical surface condensers and circulating and house-service pumps. The piping is arranged to dispense with all steam traps. An indicating panel in the boiler room, controlled by the switchboard operator in the turbine room, notifies the firemen when a machine is to be started and also the load being carried.

About one year ago H. M. Byllesby & Co. effected a consolidation of the five electric and two gas companies which had hitherto been operated separately in Louisville, Ky. These plants are now operated by the Louisville Gas & Electric Co.

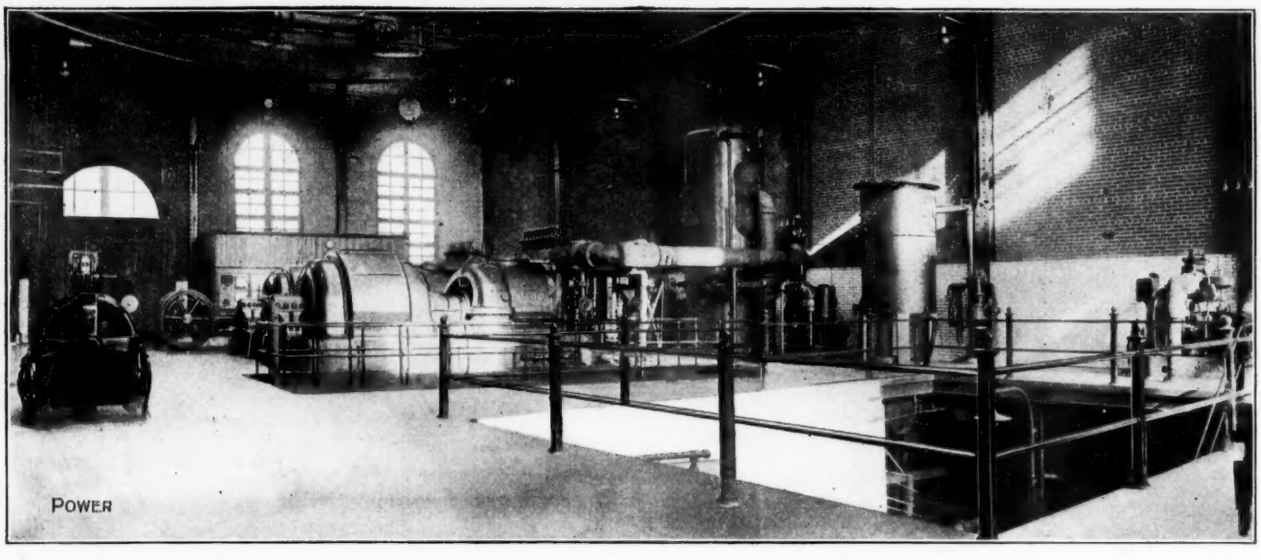


Fig. 1. Turbine Room of the Waterside Station of the Louisville Gas & Electric Co.

The Waterside station, formerly belonging to the Kentucky Electric Co., and the 14th Street station of the former Louisville Lighting Co., are connected by tie lines and supply electrical energy for the city and suburban territory, the other smaller plants being shut down. The Waterside station, on the river front, is the more modern, having been built about eighteen months ago. Although there is but one 2000- and one 4000-kw. turbine unit, the station is designed for an ultimate capacity of 64,000 kw. At the present time extensive additions are in progress of construction.

The two turbines, Fig. 1, are housed in a building 134 ft. wide by 107 ft. long. The building is three stories high, exclusive of the basement, and the boiler and the turbine-room floors are on the same level. The two galleries on the left side of the turbine room are devoted to switch and busbar compartments and to lightning-arrester apparatus.

Condenser Pit

An interesting feature is the arrangement of the condensers in a pit 52 ft. 3 in. below the turbine-room floor and 30 ft. in diameter. This arrangement was made necessary by the 45-ft. rise and fall in the stages of the Ohio River at the plant site. The well is built of concrete, with walls 4 ft. thick. The barrel-shaped intake and discharge tunnels, Fig. 2, are below the bottom of the condenser well, and are 8 ft. long and 7 ft. high at the center. Water is taken from the river through a concrete screen well which is 535 ft. from the two concrete intake cribs, 75 ft. apart, and carried through two cast-iron flanged pipes with flexible joints. From the river waterline 42-in. concrete pipes extend to the screen well, made with two compartments, each connecting with a 42-in. supply pipe; the screens are placed diagonally across each compartment, Fig. 3. The well is connected to the condenser pipe by concrete intake tunnels, Fig. 2. The top of the upper tunnel is between four and five feet below the average low-water mark, and the siphon principle assists in circulating the cooling water through the condensers. Either tunnel can be used as an intake or discharge by means of valves arranged in the pipes leading to the river. By reversing the flow, any sediment that collects can be washed out.

Fig. 4 is a view of the condenser pit taken from the turbine-room floor. There are two specially designed vertical, double-pass condensers, each with 10,000 sq.ft. of cooling surface. The No. 18 gage tubes are 1 in. in diameter and 14 ft. 9 in. long. Each condenser is capable of taking the steam from a 4000-kw. turbine and is connected to its turbine by a 60-in. pipe which enters the condensers at the side. The 8-in. air pipe is taken out at the opposite side and extends up to the 14 and 8 by 18-in. dry-air pumps at the back of the 2000-kw. turbine, as in the plan view, Fig. 10. The 20-in. tri-rotor circulating turbine-driven pumps are each capable of delivering 9000 gal. of water per minute against a 15-ft. head. There is also a 4-in., two-stage hotwell pump on the end of each

circulating-pump shaft, with a capacity of 200 gal. per min. The general arrangement and details of the condensers, pumps and piping in the condenser pit are shown in Fig. 5. The 20-in. suction pipe from the intake tunnel terminates at an angle valve at the top and the short 20-in. discharge pipe enters the condenser through the bottom head.

In order to determine the condition of the screens in the intake well, floats have been placed in the tunnels and

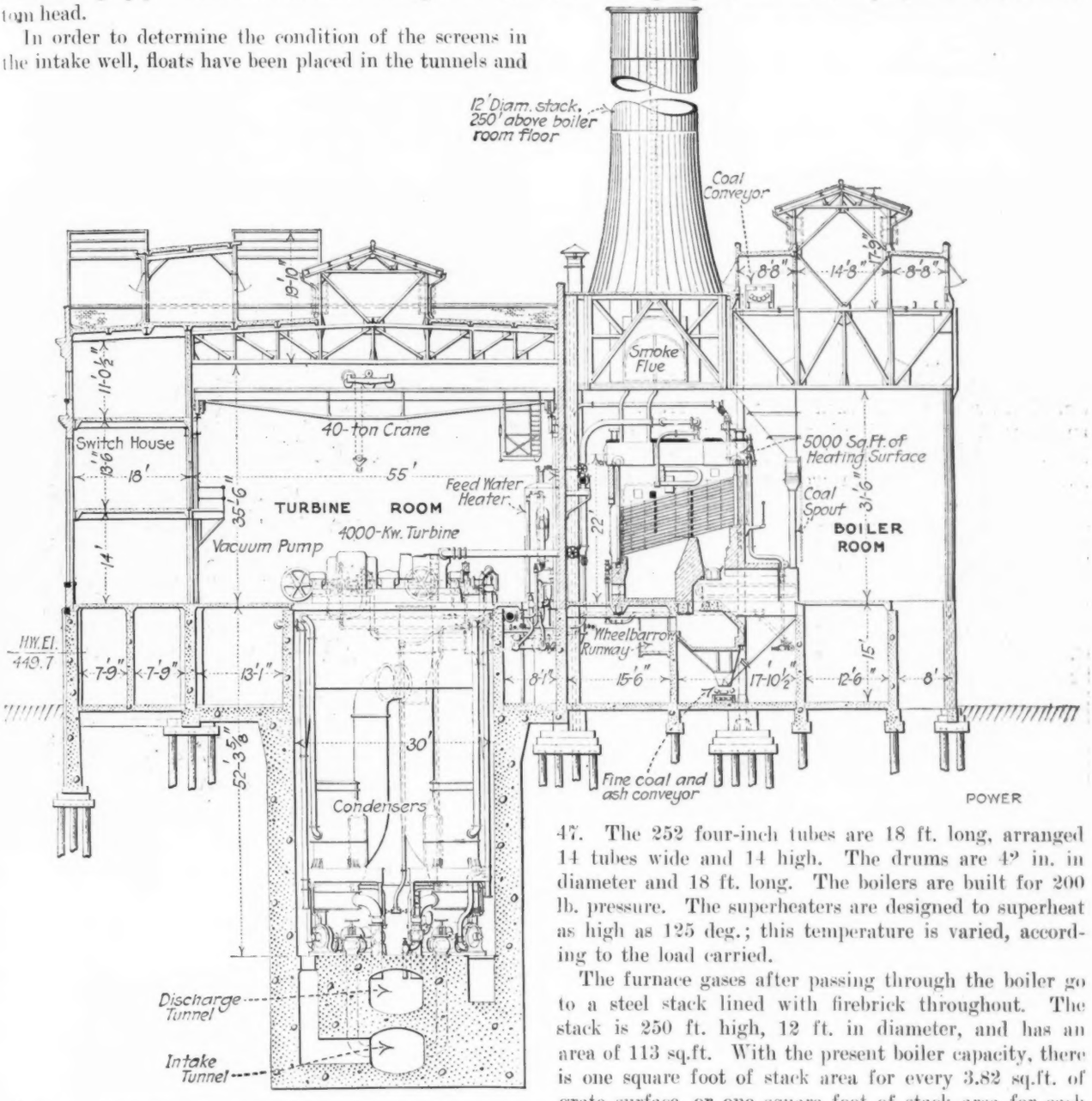


FIG. 2. ELEVATION OF THE POWER PLANT, SHOWING THE CONDENSER WELL

connected to graduated indicating tapes so brought up through vertical pipes that the operator on the turbine-room floor can determine by the gage reading the difference in the water level in the pipe, which corresponds to the friction head required to force the water through the screens and tunnel. It is contemplated to so improve this device that recording chart records may be made.

BOILER ROOM

The four water-tube boilers are arranged in batteries of two, in a single row, with room for two more in the same row, and when the proposed extensions are made there will be room for six additional boilers in a second row opposite with a 30-ft. firing aisle between. The present 500-hp. boilers, Fig. 6, each having 5087 sq.ft. of heating surface, are equipped with chain-grate stokers, each having a grate area of 108 sq.ft., or a ratio of 1 to 47. The 252 four-inch tubes are 18 ft. long, arranged 14 tubes wide and 14 high. The drums are 42 in. in diameter and 18 ft. long. The boilers are built for 200 lb. pressure. The superheaters are designed to superheat as high as 125 deg.; this temperature is varied, according to the load carried.

The furnace gases after passing through the boiler go to a steel stack lined with firebrick throughout. The stack is 250 ft. high, 12 ft. in diameter, and has an area of 113 sq.ft. With the present boiler capacity, there is one square foot of stack area for every 3.82 sq.ft. of grate surface, or one square foot of stack area for each 17.7 boiler-horsepower rating. When the other two boilers are placed, the ratio of stack area to boiler-horsepower will be as 1 to 26.5. The stack is supported by steel beams, so that the bottom is above the turbine-room roof; Fig. 2 shows the arrangement and the smoke flue. The brick lining is 4 in. thick at the top and 6 in. at the bottom. To prevent corrosion, grout is used between the brick lining and the steel shell.

Feed water is supplied by three turbine-driven, 4-in., 4-stage turbine pumps discharging against a head of 225 lb., with a capacity of 450 gal. per min.; these pumps are in the basement under the turbine room. The hot-well water for boiler feed and all makeup water in the

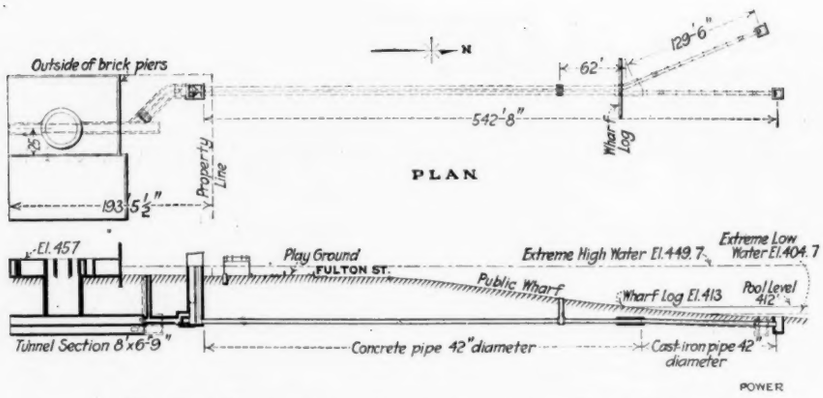


FIG. 3. PROFILE AND SECTION THROUGH EAST PIPE

jackets of the dry-vacuum pumps and turbine bearings is passed through filters.

Although coal is now delivered by rail, the plant is so located that when arrangements have been made, it can be received by boat. It is dumped into concrete bunkers below a spur track and then hoisted by a 1.5-cu.yd. clamshell bucket and emptied into a set of crushing rolls on the roof. The crusher has a capacity of 65 tons per hour. If the coal does not require crushing, it is delivered to a 24-in. belt conveyor running over the 50-ton

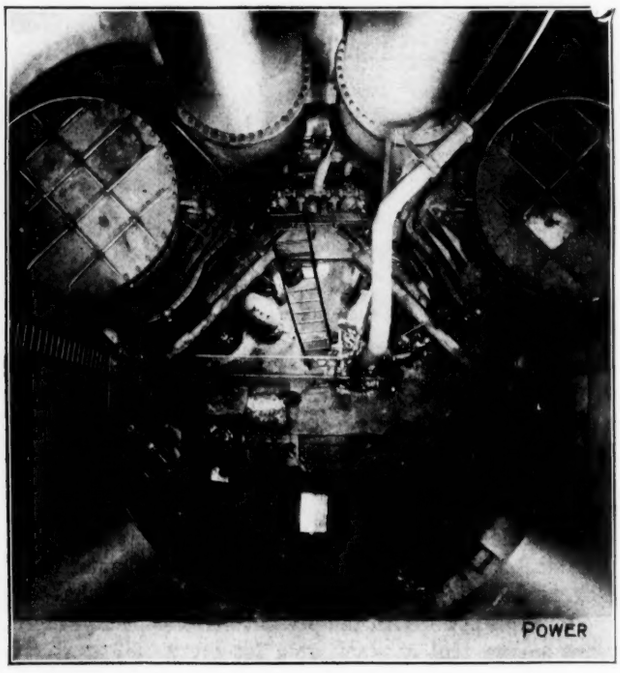


FIG. 4. VIEW OF THE CONDENSER WELL FROM THE TURBINE-ROOM FLOOR

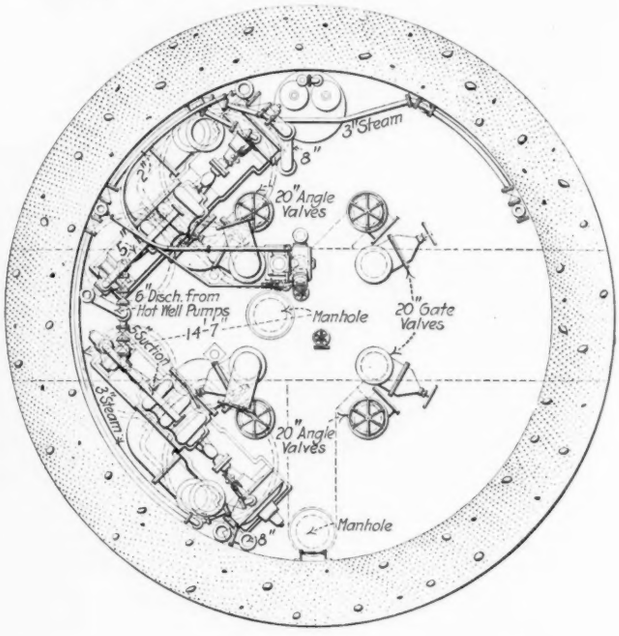
capacity bunkers. The hoist is operated by a 112-hp. motor, the crusher by a 30- and the conveyor by a 5-hp., 220-volt, three-phase induction motor.

The boiler ashpits are made in two compartments, one for the fine coal sifting through the stokers and the other for the ash. Under the hoppers is a 30-in. conveyor belt for handling either the ash or fine coal sifting. The ashes are discharged into a concrete ash bin outside of the plant, from which they are loaded into railroad cars by the coal-hoist bucket.

Steam from the superheater of each set of two boilers is piped to a 10-in. lead connecting with a 12-in. steam header next to the wall in the boiler room. From this header a 10-in. branch line goes to each main turbine. Expansion loops, placed horizontally over the boilers, relieve the pipe system from strains.

Feed water is supplied through either the main 5-in. header or the 5-in. auxiliary boiler-feed line; both are piped to the boiler-feed pumps.

Exhaust steam from the pumps and auxiliary turbines is piped to a main feed-water heater in the turbine room. All steam traps have been eliminated by drains arranged for the high-pressure steam mains. The main header and the 10-in. supply pipes to the main turbines drop 12 ft. and pass in through the separating wall to the tur-



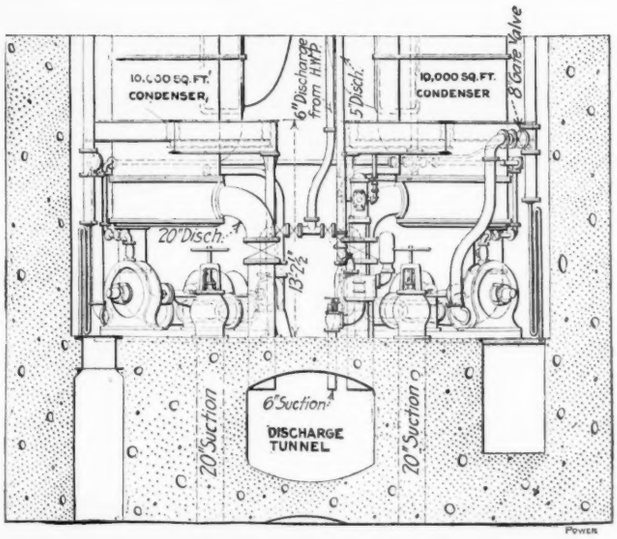


FIG. 5. PLAN AND ELEVATION OF THE CONDENSER WELL

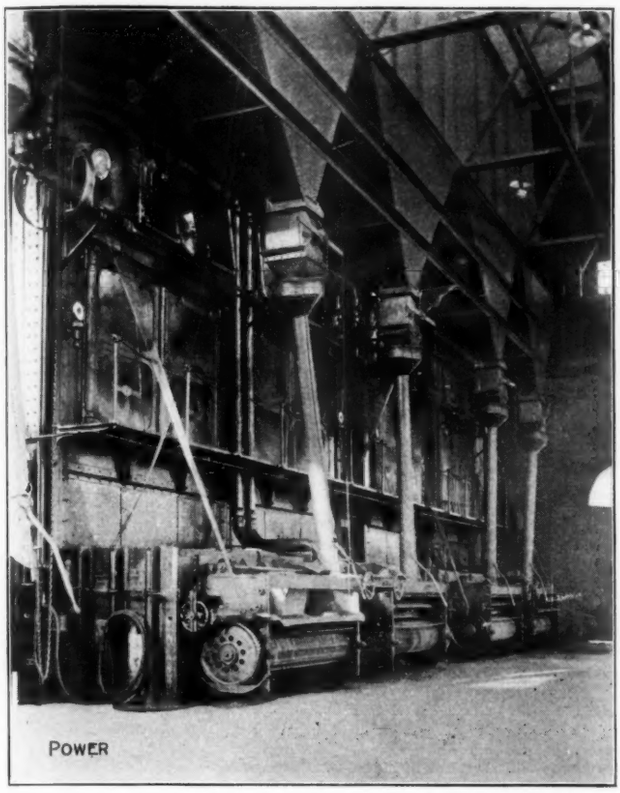


FIG. 6. FOUR 500-HP. WATER-TUBE BOILERS

bines. A 3-in. pipe connects with the bottom of the elbow, where the 10-in. pipe makes the turn and is carried to the house pumps in the bottom of the condenser well. All supply-pipe lines to the auxiliary units are taken from the top of the auxiliary header. From the bottom, two connections are taken from the under side of the header and piped to the reciprocating house pumps at the bottom of the condenser well. By this arrangement, Fig. 7, all water of condensation goes to the service pumps and is disposed of through the exhaust to the heater.

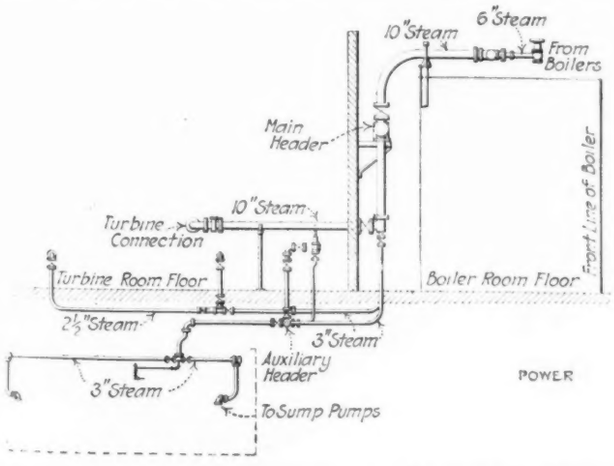


FIG. 7. PIPING ARRANGEMENT TO ELIMINATE STEAM TRAPS

BOILER-ROOM INDICATOR

An interesting indicating system has been arranged whereby the operator can signal to the fireroom the load to be carried, thus giving information of the amount of steam required at any time.

The system has an indicating panel, Fig. 8, in the boiler room, where it can be seen from the firing aisle by the firemen. The casing is 6 ft. high and 1 ft. wide. The panel face is numbered from 500 to 4500 kw. at 500-kw. intervals. Back of the face are incandescent lamps which illuminate the load number to be carried by the turbines. The lamps are connected to an operating switch, Fig. 9, at the switchboard in the turbine room, the switch being a handle with a sliding contact which can be brought over any one of the 12 buttons, or bridge any two buttons, if desired.

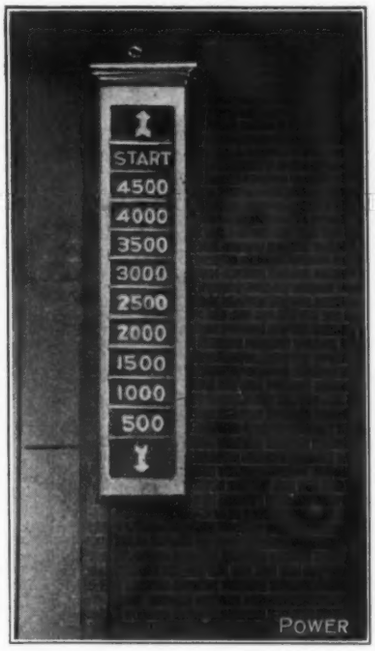


FIG. 8. INDICATING BOARD

Each button corresponds to a panel on the signal load. When the handle is placed at, say, 3000 on the switch, the lamp back of the corresponding figure on the indicating board is lighted. If the load is between 3000 and 3500 kw., the two corresponding contacts are bridged by the handle, thus lighting both indicator panels. Should it be necessary for the operator to start a second turbine, the switch handle is moved to the "start" contact before the machine is started up. In conjunction with the signal panels there is a return call bell controlled by three-way switches.

In case the fireman is in doubt as to the load being carried, due to the operator's failure to change the panel, a three-way switch is pushed which lights up two arrows similar to those shown at the top and bottom of the indicator, on the desk board. The operator then either

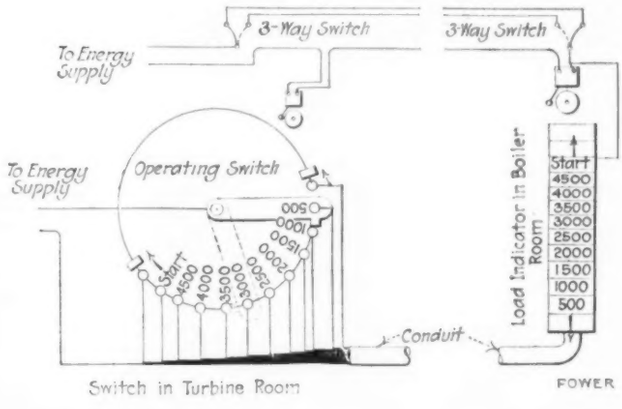


FIG. 9. CONNECTIONS OF CALL BELL AND INDICATOR MECHANISM

changes the indicator according to the load carried or lights up one or the other of the arrows in the boiler room, indicating that the load will either increase or decrease.

Auxiliary Electrical Units

Exciting current is supplied to the main generators by a 100-kw. turbine-driven, 125-volt generator at 2400 r.p.m., or by a 150-hp. motor driving a 100-kw., 125-volt direct-current generator at 900 r.p.m. There is also a 5.5-kw., 220-volt motor generator for supplying energy for charging the storage batteries used for switchboard control.

One 500-kw. synchronous motor-generator set, in the turbine room, furnishes 600-volt direct-current service. This set is operated by 6600-volt, three-phase energy and supplies current at 600 volts for the commercial motor circuits. It is designed for 70 per cent. power factor correction.

At the north end of the plant is the operating engineer's office. The switchboard is at the side of the building at the opposite end of the turbine room.

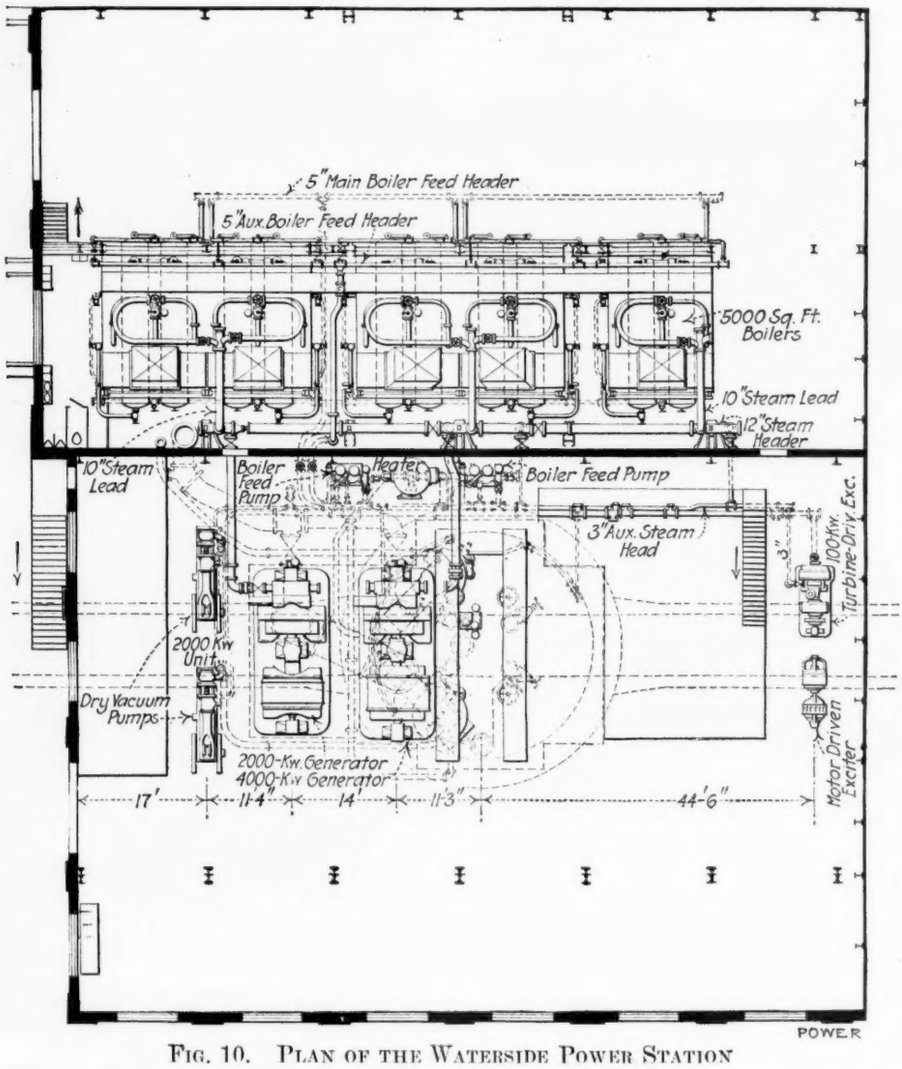


Fig. 10. Plan of the Waterside Power Station

PRINCIPAL EQUIPMENT OF STATION B (WATERSIDE) OF THE LOUISVILLE GAS & ELECTRIC CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbo-generator	Curtis, G. E.	2000 kw	Main units	1800 r.p.m., 2300-4600 volts, 175 lbs. steam	General Electric Co.
1	Turbo-generator	Curtis, G. E.	4000 kw	Main units	1800 r.p.m., 2300-4600 volts, 175 lbs. steam	General Electric Co.
2	Condensers	Surface	10,000 sq.ft.	With turbines	28-29 in. vacuum	Alberger Pump & Cond. Co.
4	Boilers	B. & W.	500 hp.	Steam generators	185-lb. steam, 125 deg. superheat	Babcock & Wilcox
4	Superheaters	B. & W.	500 hp.	Steam boilers	125 deg. superheat	Babcock & Wilcox
2	Pumps	Dry air	14x8x18-in.	On condensers	Separate, with interconnection	Alberger Pump & Cond. Co.
2	Pumps	Circulating tri-rotor	20-in., 9000 gal. capacity	With condensers	Work against 15.-ft. head	Alberger Pump & Cond. Co.
2	Turbines	Single stage	200 hp.	Driving tri-color pumps	1300 r.p.m., 185 lb. steam	Alberger Pump & Cond. Co.
2	Pumps	Single-stage	4-in.	Hot well	Mounted on shaft of circ. pump	Alberger Pump & Cond. Co.
1	Chimney	Steel, brick lined	250 ft. high, 12 ft. diam.	Furnace gases	Natural draft	Kennicott Co.
3	Pumps	Four-stage	4-in.	Boiler feed water	9700 r.p.m. turbine driven	Alberger Pump & Cond. Co.
1	Turbine	Single-stage	150 hp.	Driver boiler feed pump	9700 r.p.m., 185 lb. steam	General Electric Co.
2	Turbines	Single-stage	150 hp.	Driving boiler feed pumps	2700 r.p.m., 185 lb. steam	Terry Steam Turbine Co.
1	Coal hoist	Clamshell bucket	1.5 cu.yd. cap.	Hoisting coal	Intermittent	Orton & Steinbrenner
1	Crusher	Coal	65 tons per hour.	Crushing coal	Intermittent, by motor	Orton & Steinbrenner
1	Conveyor	Belt	30-in.	Ash or fine coal sifting	Intermittent	Robins Belt Conveying Co.
1	Turbo-generator	Steam, D.c	100 kw.	Exciter unit	185 lb. steam, 125 volts, 2400 r.p.m.	General Electric Co.
1	Motor-generator	A.c., D.c	150 hp., 100 kw.	Exciter unit	900 r.p.m., 125 volts	General Electric Co.
1	Motor-generator	A.c., A.c.	5.5 kw.	Charging storage batteries	Intermittent, 220-volt	General Electric Co.
1	Motor-generator	Synchronous	500 kw.	Power service	600-volt	Westinghouse Elec. & Mfg. Co.
1	Feed water heater	Open, 5" back pressure	2000 hp.	Boiler feed water	Continuous	Platt Iron Works Co.
1	Crane	Electric, A.c.	40 tons & 5 tons	Turbine room equipment	220 volt, A.C., intermittent	Northern Crane Co.

Refuse from Intake Tunnel

Refuse from Intake Tunnel

The photographs, Figs. 1, 2, 4 and 5, show refuse taken from an 8x8-ft. condensing-water intake for the Sixty-sixth Street station of the Edison Electric Illuminating Co. of Brooklyn, N. Y. The refuse represents an accumulation of about eight years.

To clean the tunnel the entrance was closed by the winch-operated gate, Figs. 3 and 4, and a small motor-driven centrifugal pump used to empty it and pump out the leakage. Notice the heavy timbers in the foreground of Fig. 1. These timbers had long heavy bolts, I-beams and stones fastened to them, evidently to keep them submerged. The accumulation is chiefly wood and mud, tons being taken out. The cleaning was done on Sunday while the station load was carried by the Gold Street station.

Durability of Iron and Steel Pipe

By William Hirst

SYNOPSIS—Suggests reasons why steel pipe sometimes corrodes faster than the wrought-iron. Points out the tendency to overlook the differences of compositions of metals in pipe subject to test, thus lowering the value of test results.

Manufacturers of steel pipe maintain that there is no difference in the durability of iron over steel pipe, yet, while favoring the use of steel because of its strength and uniformity, the writer's experience—extending over twenty-six years in rolling mills, where both metals were in process of manufacture, and eight years in a rubber manufacturing concern using iron and steel forms—teaches him that there is a substantial difference.

Years ago, when steel shapes were being introduced, it was noticed that steel exposed to the weather rusted rapidly and soon became unsalable, while iron suffered comparatively little. The iron, being rolled at a much higher temperature, formed a thick coat of scale over its surface which undoubtedly protected it, but, aside from that, it was found that iron was less oxidizable than steel.

During the eighties a man approached our firm with a proposal to make wire door mats. It was suggested that his idea was impracticable because the steel ordinarily would be a mass of rust in a few weeks. He showed, however, that he had a steel that was practically rustless; it subsequently proved to be heavily alloyed with nickel, dispelling the idea that steel could not be made as rustless as iron.

Kent states on page 674 of his handbook: "The resistance to corrosion increases with the percentage of nickel up to 18 per cent. This alloy is practically incorrodible." Of course, an alloy that high is impracticable, but it shows what can be done. There are other alloys which tend to make steel better in this respect, and it seems remarkable, in view of the possibilities, that steel should be more corrosive than iron.

The question of the durability of iron and steel pipe has been discussed until it would seem that the subject was exhausted. Tests have been made in laboratories and other places to determine which was the least affected by corrosive elements in the fluids passing through or over iron and steel. The results are not conclusive; they sometimes favor one, sometimes the other, and thus the user is left to his own judgment. There may be, and doubtless is, steel pipe made that will rust as little as iron, but it can be safely stated that the general run of steel pipe is inferior to iron pipe not only in this respect, but in the perfection of its weld and its workable qualities in the dies.

As used in the manufacture of pipe, steel is undoubtedly purer, more homogeneous and has greater strength and ductility in the softer grades of steel from which pipe is made. It is of one kind, one degree of ductility and one hardness. Iron is fibrous, it is often made up of bars of scrap, and it contains more or less foreign matter between the layers. Knowing this, it seems anomalous that iron pipe should be preferred to steel. If it were a matter of strength alone, steel would best meet the requirement, but strength is often secondary; the ability of the metal to resist the corrosive action of the fluids in contact with it is the prime consideration.

As to which is the least oxidizable and will last the longer without grooving, many prefer iron, and that, too, without prejudice. Users decide for one or the other according to their experience, and this is the best way.

Iron has been found to resist the scoring and corrosive action of the discharge from vulcanizers where some kind of acid is generated by the steam from the compounds used in making rubber goods. It has also been found to last longer than steel when used for open returns carrying condensate and vapor from heating coils. In the former case, the discharge from these vessels will cut through the partition in a brass globe valve in a comparatively short time; an iron-body gate valve will outwear them, but an iron asbestos-packed cock is best. With experience like this and with better prices urging the use of steel pipe, we naturally ask, what is there in iron that enables it to resist the destroying elements better and longer than steel?

We are told that chemically pure iron exists only as a curiosity in the metallurgist's laboratory, and that as a pure metal it cannot be considered as a substance of practical importance. With certain metallic or nonmetallic substances with which it is found, or which are added as alloys, however, it becomes useful for an infinite variety of purposes. When we consider that, no matter to what process of refining the products called iron or steel may have been subjected, their base is iron, they are alike, and whatever difference there may be in the products it is due to composition, to the process of manufacture, or to both.

If either has an advantage, we may safely assume that it is the presence of substances chemically combined. Wrought iron commonly contains sulphur, phosphorus, silicon, carbon and cinder or slag. In an analysis of a good wrought iron, the cinder and silica predominate. These may be said to be noncorrosive substances, and there is no doubt that whatever degree of superiority wrought iron may have over steel, it is due to the presence of these substances. The total percentage of impurities in a good grade of iron is given at 1.345, of which 1.168 is cinder, 0.067 phosphorus, 0.065 silica and 0.045 carbon. Here we have a noncorrosive agent or agents more or less evenly distributed throughout the mass, protecting, in a measure, the particles of pure iron.

An analysis of soft bessemer steel is given as containing a total of 0.605 per cent. of impurities, the amount of silica being 0.135, carbon 0.126; cinder not mentioned. An analysis of open-hearth steel shows a still greater degree of purity, the total impurities being 0.385, of which carbon is 0.167, silicon 0.023. In comparison, would not this steel, because of its purity, rust much quicker than iron? The softer and purer steel or iron may be, the more susceptible to rust either becomes. It would therefore seem that to make them less susceptible, the particles of pure iron must be protected by some substance held in chemical combination, as is the

graphitic carbon found in gray cast iron. The substance may be found in the metal itself, it may be taken up in the process of manufacture, or added as an alloy. It is well known that cast-iron pipe will last long in soil which would destroy wrought-iron or steel pipe in five years. Wrought pipe has been guttered and cut through by the condensate passing through it while the cast-iron fittings were scarcely marked.

Referring to a metallurgist's analysis, we find that the percentage of impurities in cast iron is from six to ten, in which carbon is as much as four and silicon as much as 2½ per cent. The value of carbon as a protective agent is well known. Sand and glass are forms of silica, and for our purpose would be considered rustless. The point to be deduced is that the ability of steel or iron pipe to resist destruction by corrosive agents is largely due to the impurities in the metal or to an alloy; that steel for making pipe can be alloyed to make it superior to iron, and no one need hesitate to use such steel pipe in preference to genuine wrought iron. While this is true, it is equally true that the general run of steel pipe is not made in this way.

Those who have machined both iron and steel know that good steel is easier to work, as it is more even in its structure and density. If, in addition to these qualities, we could be assured of a composition calculated to make it less oxidizible than iron, while retaining all the good qualities in respect to making a perfect weld and ease of working in the dies, all apprehension would be removed.

No account is taken, usually, of the composition of the steel or of the grade of the iron in pipe subject to tests for durability. Steels for various purposes are made to specifications, and why not for pipe? With this knowledge a comparative test would have some value; it would be better than the results of the comparisons of unknown compositions under conditions perhaps much different than those in other tests.

Washed Air for Cooling Transformers

By Melvin Hall

SYNOPSIS—An argument pointing out the desirability of washing and cooling the air blast to transformers, as an aid to overload capacity, regulation, efficiency and durability in service.

The particular application of the air-blast transformer is in stations or substations of reasonably large capacity, where space is not too limited, or where water for the water-cooled type cannot be conveniently or cheaply obtained, and where the capacity of the ordinary oil-cooled type is not great enough. Its application is limited to those stations which do not demand voltages much in excess of 35,000 volts, and it is often used instead of the oil-cooled type to avoid increased risk from fire. The damper control is also advantageous.

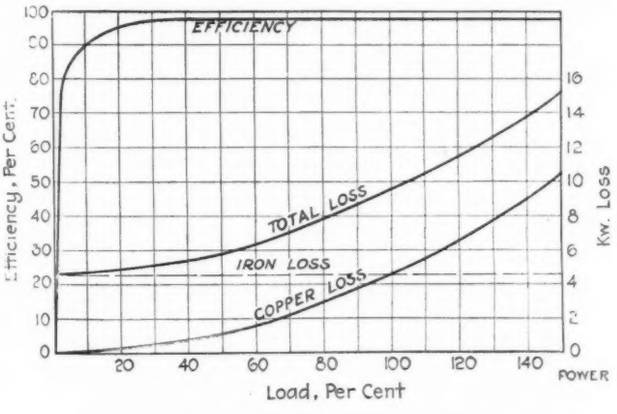


Fig. 1. Transformer Characteristics

Capacity for Overload

The actual output of a transformer is limited to a smaller value than the theoretical; first, because of the necessity of cool running; second, because the secondary electromotive force must be nearly constant, and third, because of the drop in efficiency at excessive outputs. The output of large transformers is directly limited by rise in temperature. Naturally, in the air-cooled type, this rise (other things being equal) is due to the air conditions, for if the heat is dissipated rapidly enough the temperature will be held normal.

The full-load rise for transformers is recommended to be not over 50 deg. C. (by resistance measurement) and 40 deg. C. by thermometer; and with an overload rating of 25 per cent. for two hours, an allowable increase of 15 deg. C. above that specified for full load. Increasing the output in the ratio of 6 to 5 increases both primary and secondary I^2R in the ratio of $36 \div 25 = 1.44$ times the normal copper loss. Also the resistance of copper changes rapidly with the temperature, so it is of prime importance to keep the temperature down.

When transformers are to be used with turbo-generators or other apparatus for which an overload capacity in excess of 25 per cent. is guaranteed, the transformer should have a corresponding overload capacity. This overload capacity from generators is made possible through use of the air washer; therefore it would seem reasonable that the transformers should be similarly equipped. The general curves of Fig. 1, plotted by W. Esty, illustrate a few transformer characteristics.

Durability

The life of a transformer depends primarily upon its ultimate temperature, since an excessive rise causes rapid deterioration in the insulation. The fact that apparatus which is kept clean will last longer than that which is periodically allowed to become dirty and then cleaned is never denied.

Regulation

Regulation by direct measurement is defined as the difference between no-load secondary voltage and full-

load secondary voltage, divided by full-load secondary voltage, when a constant primary voltage is maintained. It has a decided bearing on the question of lamp life and uniformity of light.

The general formula used in practice for calculating the regulation with an inductive load is

$$per\ cent.\ regulation = p + \frac{q^2}{200}$$

where

p = Component of drop in phase with the terminal voltage;

q = Component in quadrature with the terminal voltage.

Its solution shows that regulation is largely a function of copper loss and should not be neglected. The copper loss being a function of resistance, it is easily seen that to improve the regulation requires that the transformer be kept cool.

Safety

The advantage of air-blast over oil-cooled transformers as regards safety has been referred to; a leak in a water-cooled transformer is equally disastrous. Breaking down of insulation is due either to overheating or to a high voltage discharge through damp insulation and foreign matter. The first of those causes will be discussed under "Heating."

If a high voltage is allowed to pass from the primary to the secondary or *vice versa,* thence into buildings, it endangers human life and makes loss of property by fire probable. The insulation is originally of good quality and able to exclude moisture; but the dirt from a dirty air supply clogs the ducts in the windings and decreases the dielectric strength to a great extent, especially if the intake air is wet. The best safeguard is to supply clean, cool air in sufficient quantity and without free moisture. The air-washer supplies this through the use of dense sprays and eliminator plates. The eliminators fulfill the function of preventing free moisture from getting into the apparatus.

Heating

Vigilance is required in the problem of dissipating self-generated heat as rapidly as generated. This heat is proportional to the losses, which in turn are proportional to the cube of the linear dimensions. Since the ratio of radiating surface per kilowatt decreases rapidly with the increase in size, rise in temperature is the limiting feature in the economical manufacture of large transformers.

The best results with air-blast transformers can be attained only with a supply of cool, clean air, with provision for lowering the inlet air temperature in case of peak load or emergency. The effect of a soot, dust, vapor or water- and snow-laden air supply is well known. The foreign matter soon covers the radiating surfaces, rendering them inefficient as such, blocks the air passages and causes local or general abnormal heating; this will cause even the best insulation to deteriorate. An idea of the conditions may be had by noting the case of generators given by E. Knowlton:

	Dirty	Clean
Machine Number 1, Rise in Temperture,	54	37
" " 2. " "	54	41

Guarantees usually prescribe that at normal load the temperature shall not exceed 40 or 35 deg. C. above the surrounding air. The discharge temperature of the air should not be more than 20 deg. C. above the temperature of the supply, and the General Electric Co. recommends a temperature of incoming air not greater than 25 deg. C. The amount of air should be about 150 cu.ft. per min. for each kilowatt loss, or 4 cu.ft. per min. per rated kilowatt at about 4 oz. pressure. In case of breakdown of a blower, it is unsafe to operate at more than half load, and even at that load for long.

Air washers are on the market that will guarantee to remove 98 per cent. of the foreign matter and cool the air from 2 to 32 deg. F., depending on the entrance temperature and relative humidity, by recirculating the water. On peak load, the air may be cooled down even more by using water direct from the mains. Thus the washer decreases the heating of the transformer directly by cooling the intake air and indirectly by preventing troubles due to a dirty air supply. Usually the air exhausts from the transformers directly into the station, in which case the air washer serves the additional purpose of purifying the station supply. Again, the advantage is manifest when one compares the statement in the last paragraph concerning fan breakdown with the following claims for the air washer: "When sprays are operating at 25 lb. pressure they will force the air through the washer against atmospheric pressure at a velocity of not less than 225 lin.ft. per min., by driving action of the sprays alone, independent of the fan."

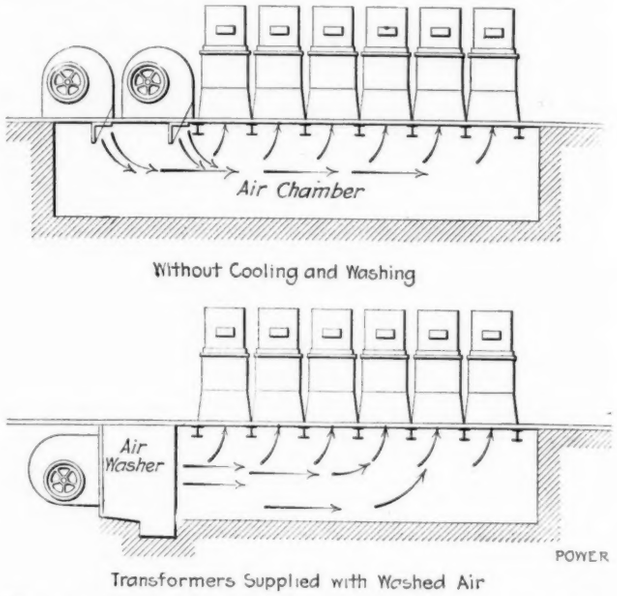


FIG. 2. BANK OF TRANSFORMERS WITHOUT AND WITH AIR WASHING

Several manufacturers recommend that their transformers be cleaned at least once a month. Because of the bother, lack of implements and time, however, this is not always done. With the air washer this cleaning is not necessary. Also, some of the ducts which ordinarily become restricted are inaccessible for cleaning.

Efficiency

Referring to the efficiency curve, Fig. 1, it will be noted that the core loss is constant. At full load the core loss equals the I^2R loss, and above this point the greatest loss is the I^2R, which increases rapidly. Although transformers are inherently highly efficient (from

95 to 98 per cent.), the raising to 98.5 per cent. would mean a saving of 50 kw. per hr. on a 10,000-kw. installation, which in the course of a year would amount to a large item. The increase in efficiency is easily found by the general methods for any particular station.

$$efficiency = \frac{output}{output + core\ loss + I^2R + power\ to\ drive\ auxiliary\ apparatus}$$

Cost of Operation

The cost of operating a set of air-blast transformers being known, the station manager would desire to know the additional cost of operation as well as the net saving due to the installation of the air washer. Since one of the guarantees which go with the washer is that the safe overload capacity of the transformer would be increased, it is natural that this advantage will be taken. If a transformer is to be operated on light loads the greater part of the day, it is much more economical to use one designed for a small iron loss than for a small full load copper loss. Under these conditions, the air washer running on peak load will keep down both of these operating expenses.

Since the rates and conditions are so widely different in different stations, no attempt will be made to figure the saving in an actual case; however, an outline of the points to be considered in the comparison of operating costs will be given:

Without Air Washer	With Air Washer
Core loss in per cent. of kw. rating (about 1%)	Slightly less
Copper loss in per cent. of kw. rating.	Less
Power to drive blower 1 to 5 per cent.	Plus power to drive pump minus power delivered by driving action of sprays
Price	Plus cost of air washer
Interest and depreciation	Same, plus that on cost of air washer
Cost of cleaning once per month	None

The writer believes that this proposition is worthy of careful investigation by those having facilities for making the necessary tests.

Transmitting Power by Compressed Air

By L. L. Brewster

SYNOPSIS—Efficiency of transmitting power through air pipes, determining the flow of air and the friction during transmission.

While much has been written about the transmission of power by flowing air under pressure through piping systems, a great many are apt to confuse the transmission of air and the transmission of power and the formulas by which both quantities are calculated. For instance, those unfamiliar with the subject are apt to err in assuming that the loss of power is proportional to the loss of pressure, as in the case of transmitting power through piping by water.

It is quite correct to use the ordinary formulas for the flow of air through piping to calculate the amount of air transmitted and its initial and final pressure, but these formulas are not in themselves altogether sufficient for calculating the amount of energy or power of the air at the beginning and end of the transmission system. The more accurate measure of the efficiency of transmitting air through pipes is to credit the air with all of the energy it can develop by isothermal expansion, both at the entrance to the pipe and at the exit; the efficiency of transmission being the latter quantity divided by the former. The work done in the isothermal expansion of a given amount of air may be calculated from the equation

$$w = p_1 v_1 \log_e r$$

in which

w = Work in foot-pounds;
p = Absolute initial pressure;
v = Volume of air at the beginning of compression;
r = Ratio of the absolute initial pressure to the absolute final pressure.

The potential amount of work which a given quantity of air at the end of the transmission system could do by isothermal expansion is represented by a similar formula, but it is evident that while in both cases the air may be isothermally expanded to atmospheric pressure, the initial pressure before transmission must be higher than that at the end of transmission, so that the value of r will be different in each case. The mathematical expressions for the work done by isothermal expansion for the air at the end and the beginning of transmission respectively simplifies to the following expression when the former is divided by the latter, and this is, therefore, the equation for the efficiency; that is,

$$efficiency = \frac{\log_e r_2}{\log_e r_1}$$

r_2 being the ratio of expansion at the exit pressure and r_1 the ratio of expansion at the inlet pressure. Common logarithms may be used since the modulus cancels and the expression thus reduces to the form

$$E = \frac{\log r_2}{\log r_1}$$

The efficiency of transmission for several pressures is shown in Table 1. The figures at the head of the two sets of data indicate the initial absolute pressure (87 lb. and 145 lb. per sq.in. respectively), the absolute pressure to which the air is expanded in all cases (14.5 lb. per sq.in.), the initial ratios of expansion (6 and 10) and the logarithms of these ratios (0.7781 and 1). It is evident from the table that when the absolute pressure at the end of the transmission system is as shown by the figures at the top of the several columns, the ratios of expansion and the efficiencies are indicated by the figures directly under.

TABLE 1. EFFICIENCY OF TRANSMISSION

$p_a = 14.5$ $p_1 = 87$ $r_1 = 6$ $\log r_1 = 0.7781$

p_2	85	80	75	70	65	60
r_2	5.86	5.52	5.17	4.83	4.48	4.14
$\log r_2$	0.7679	0.7419	0.7135	0.6839	0.6513	0.6170
E	0.987	0.953	0.917	0.879	0.837	0.793

$p_a = 14.5$ $p_1 = 145$ $r_1 = 10$ $\log r_1 = 1.$

p_2	140	135	130	125	120
r_2	9.66	9.31	8.97	8.62	8.28
$\log r_2$	0.9850	0.9689	0.9528	0.9355	0.9185
E	0.98	0.97	0.95	0.93	0.92

From the table it would appear advantageous to transmit air at as high pressure as possible. The work cannot be fully recovered without expanding down to atmospheric pressure, and this is usually impractical unless the air

is reheated, because the temperature of the air expanded to atmospheric pressure is usually so low that frost is formed around the discharge valves and passages and finally chokes the passage.

When the transmitted air is used without expansion, the efficiency of transmission is represented by the formula

$$E = \frac{r_1 (r_2 - 1)}{r_2 (r_1 - 1)}$$

Flow of Air through Pipes

The formulas which are derived purely from the mathematical considerations of the flow of air do not seem to agree with experimental results so well as do some of the empirical formulas derived principally from the results of carefully conducted tests. The problem most frequently encountered in the flow of air is that of finding the amount in cubic feet which will flow through a given size pipe in a given time under given conditions of temperature and pressure. The amount of air flowing from the receiver or tank under pressure into the atmosphere is sometimes desired, and such flow is governed by Napier's law, by which the calculated flow is approximately the same when the discharge is into any pressure less than 60 per cent. of the initial pressure.

For the amount of air flowing in power-transmission systems, the formulas of Prof. E. G. Harris are widely used for calculating the flow in small pipes, and those of W. H. Hammon for calculating that in larger pipes. For 11-in. pipes the formulas of Harris or Hammon give about the same results. For smaller-size pipes the Harris formula gives somewhat greater values for the loss of pressure and for larger pipes the Hammon formula gives slightly greater pressure drops. Hammon's formula for the loss of pressure, due to friction, is as follows:

$$P_1^2 - P_2^2 = 0.0004555 \frac{V^2 L}{d^5}$$

in which

P_1 = Absolute initial pressure;
P_2 = Absolute discharge pressure;
d = Interior diameter of pipe in inches;
L = Length of pipe in feet;
V = Volume of air per minute in equivalent cubic feet at atmospheric pressure (volume of free air per minute).

To facilitate the use of this formula, Table 2 gives values of d^5 for the standard-size pipes.

TABLE 2

Nominal Dia. of Pipe, In.	Exact Interior Dia., d, In.	d^5
1	1.048	1.266
1¼	1.380	5.000
1½	1.610	10.800
2	2.067	37.7
2½	2.468	91.5
3	3.067	271
3½	3.548	561
4	4.026	1,054
4½	4.508	1,860
5	5.045	3,270
6	6.065	8,150
7	7.023	17,100
8	7.981	32,500
9	8.937	57,000
10	10.018	100,500
12	12.000	248,000
14	14.000	538,000

The loss of pressure by friction for compressed air can, according to the tests of Professor Harris, be expressed as follows:

$$P_1 - P_2 = (0.31 - 0.00768\, d) \frac{V^2 L}{1000\, P_3 d^5}$$

or for $L = 1000$ ft.

$$P_1 - P_2 = (0.31 - 0.00768\, d) \frac{V^2}{P_3 d^5}$$

The loss by friction in transmitting air can be calculated by either of the two formulas given, but such calculations are greatly simplified by the use of Table 3, which appears in the book on "Compressed Air," by Professor Harris. The directions for using the table are given at the top.

TABLE 3. FRICTION IN AIR PIPES

Divide the number corresponding to the diameter and volume by the ratio of compression. The result is the loss in lb. per sq.in. in 1000 ft. of pipe

Cu.Ft. of Free Air per Min.	Dia. of Pipe, In. ½	¾	1	1¼	1½	1¾	2	2½	3
6	27.3	3.54	0.83	0.26					
12	108.3	14.26	3.32	1.05					
24		56.64	13.28	4.20	1.71	0.78			
36		126.4	29.86	9.45	3.84	1.75			
48		226.6	53.15	16.80	6.83	3.12	1.60		
60			84.94	26.26	10.70	4.87	2.50		
72			119.8	37.90	15.40	7.03	3.62	1.17	
84			163.7	51.46	20.90	9.55	4.91	1.59	
96				67.21	27.30	12.48	6.41	2.07	
108				85.06	34.55	15.80	8.12	2.62	
120				105.0	42.67	19.50	10.00	3.25	
150				164.1	66.53	30.47	15.66	5.06	1.85
180					96.00	43.87	22.54	7.28	2.67
210					130.7	59.71	30.70	9.91	3.63

Cu.Ft. of Free Air per Min.	Dia. of Pipe, In. 1¼	2	2½	3	3½	4	4½	5	6
240	78.00	40.09	12.94	4.74	2.13				
270	98.70	50.72	16.48	6.00	2.70				
300	121.8	62.62	20.23	7.41	3.33				
330		75.78	24.57	8.97	4.03				
360		90.29	29.12	10.67	4.80				
390		105.5	34.20	12.53	5.63				
420		122.8	39.64	14.52	6.53	2.87			
450			45.50	16.67	7.49	3.30			
480			51.88	18.97	8.53	3.75			
510			58.44	21.42	9.62	4.23			
540			65.39	24.01	10.79	4.75			
570			73.00	26.75	12.02	5.29	2.94		
600			80.90	29.64	13.32	5.86	3.25		
660			97.90	35.87	16.12	7.09	3.93		
720			116.50	42.68	19.19	8.43	4.68		
780				50.10	22.50	9.00	5.50	3.25	
840				58.10	26.11	11.48	6.37	3.76	
900				66.70	29.98	13.18	7.32	4.32	
960				75.88	34.10	15.00	8.32	4.92	
1020				85.65	38.50	16.93	9.40	5.55	2.23
1080				96.04	43.17	18.98	10.53	6.22	2.50
1140				107.00	48.10	21.15	11.74	6.93	2.79
1200					53.29	23.44	13.01	7.68	3.09
1320					64.49	28.36	15.74	9.29	3.73
1440					76.74	33.75	18.73	11.06	4.44
1560					90.05	39.61	21.89	12.98	5.22
1680					104.45	45.95	25.50	16.78	6.05

Cu.Ft. of Free Air per Min.	Dia. of Pipe, In. 4	4½	5	6	8	10	12
1800	52.73	28.23	17.82	6.95	1.65		
1920	60.00	33.30	19.66	7.90	1.87		
2040	67.74	37.59	22.20	8.92	2.12		
2160	75.94	42.15	24.89	10.00	2.37		
2280	84.60	46.95	27.65	11.14	2.64		
2400	93.74	52.02	30.72	12.35	2.93	0.96	
2520		53.38	33.87	13.61	3.23	1.06	
2640		62.96	37.17	14.94	3.55	1.16	
2780		68.81	40.66	16.33	3.88	1.27	
2880		74.92	44.78	17.78	4.22	1.38	
3000		81.30	48.00	19.29	4.58	1.50	
3300		98.37	58.08	23.34	5.54	1.81	
3600			69.13	27.78	6.59	2.16	0.87
3900			81.13	32.60	7.74	2.53	1.02
4200			94.09	37.81	8.97	2.94	1.18
4500				43.41	10.30	3.37	1.36
4800				49.39	11.72	3.84	1.54
5100				55.76	13.23	4.34	1.74
5400				62.51	14.83	4.86	1.95
5700				69.62	16.53	5.41	2.18
6000				77.18	18.31	6.00	2.41
6600					22.16	7.26	2.92
7200					26.37	8.64	3.47
7800					30.95	10.10	4.07
8400					35.90	11.76	4.73
9000					41.20	13.50	5.40
9600					46.88	15.36	6.17
10200					52.92	17.34	6.97
10800					59.36	19.44	7.81
11400					66.11	21.66	8.70
12000					73.25	24.00	9.64
13200						29.04	11.67
14400						34.56	13.89
15600						40.56	16.30
16800						47.40	18.90
18000						54.00	21.70
19200						61.43	24.70
20400						69.36	27.87
21000						77.75	31.25
22800						86.64	34.82
24000						96.00	38.58

For example, suppose it were desired to transmit 600 cu.ft. of air per minute through a 4-in. pipe, the initial pressure being 73.5 lb. abs., so that the ratio of com-

pression above atmosphere is 73.5 divided by 14.7 or 5. Thus, according to Table 3, the figure corresponding to 600 cu.ft. and 4 in. diameter—that is, 5.86—is to be divided by the ratio of compression 5, and the quotient, 1.172, will be the loss of pressure in pounds per square inch in 1000 ft. of pipe. The loss in pressure due to friction for any length of pipe other than 1000 ft. is proportional to the length, so that the figures obtained from the table may be multiplied by the length in feet and divided by 1000 for ascertaining the actual loss in any given length of pipe. Subtracting this loss of head in pounds per square inch from the initial pressure in pounds per square inch will give the absolute delivery pressure in pounds per square inch.

TABLE 4. NUMBER OF SMALLER PIPES TO EQUAL CARRYING CAPACITY OF LARGER PIPE

	Diameter of Pipe, In.															
Dia., In.	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	24
2	5.7	1														
3	15.6	2.8	1													
4	32.0	5.7	2.1	1												
5	55.9	9.9	3.6	1.7	1											
6	88.2	15.6	5.7	2.8	1.6	1										
7	130	22.9	8.3	4.1	2.3	1.5	1									
8	181	32	11.7	5.7	3.2	2.1	1.4	1								
9	243	43	15.6	7.6	4.3	2.8	1.9	1.3	1							
10	316	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.3	1						
11	401	70.9	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3						
12	499	88.2	32	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1					
13	609	108	39.1	19	10.9	7.1	4.7	3.4	2.5	1.9	1.2					
14	733	130	47	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1				
15	871	154	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2				
16		181	65.7	32	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	1			
17		211	76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2			
18		243	88.2	43	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	1		
19		278	101	49.1	28.1	17.8	12.1	8.7	6.5	5	3.2	2.1	1.5	1.1		
20		316	115	55.9	32	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	1	
22		401	146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3	
24		499	181	88.2	50.5	32	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	1
26		609	221	108	61.7	39.1	26.6	19.0	14.2	10.9	7.1	4.7	3.4	2.5	1.9	1.2
28		733	266	130	74.2	47	32	22.9	17.1	13.1	8.3	5.7	4.1	3	2.3	1.5
30		871	316	154	88.2	55.9	38	27.2	20.3	15.6	9.9	6.7	4.8	3.6	2.8	1.7
36			499	243	130	88.2	60	43	32	24.6	15.6	10.6	7.6	5.7	4.3	2 8
42			733	357	205	130	88.2	63.2	47	36.2	19	15.6	11.2	8.3	6.4	4 1
48				499	286	181	123	88.2	62.7	50.5	32	21.8	15.6	11.6	8.9	5 7
54				670	383	243	165	118	88.2	67.8	43	29.2	20.9	15.6	12	7.6
60				871	499	316	215	154	115	88.2	55.9	38	27.2	20.3	15.6	9.9

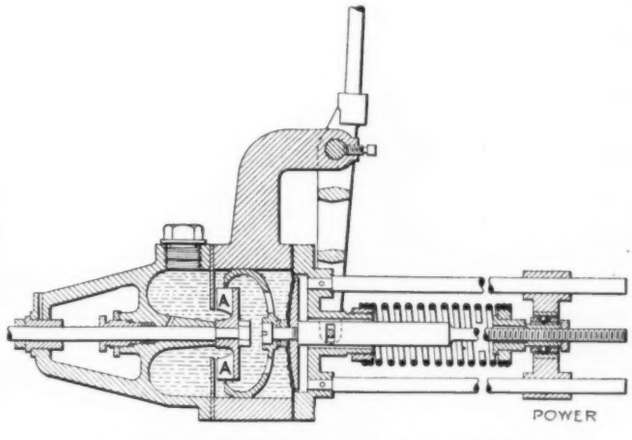
It is sometimes desirable to know the number of pipes of a given size which are equal in carrying capacity to one pipe of a larger size. It has been found sufficiently accurate for practical purposes to assume that where the head is the same, the volume delivered varies about as the square root of the fifth power—that is, as the 2.5 power. Table 4 has been calculated on this basis. The figures opposite the intersection of any two sizes is the number of the smaller-size pipes required to equal the carrying capacity of the larger-size pipe. Thus, one 8-in. pipe will deliver the same quantity of air under the same conditions as 1.4 seven-inch pipes; 2.1 six-inch pipes; 5.7 four-inch pipes; 11.7 three-inch pipes; 32 two-inch pipes, etc.

The common problems connected with the transmission of power by compressed air should be easily solved by the use of the formulas and tables given herewith, and while extreme accuracy is impossible, it is the opinion of the best authorities that the result obtained will more nearly agree with actual practice than would be the case if many of the other formulas and tables were used. For the solution of the more complex problems involving the reheating of air, the reader should consult the textbooks of some standard authority.

Centrifugal Pressure Governor for Steam Turbines

We have previously referred to a governor built by the Sulzer Bros. of Switzerland, which consisted of a small centrifugal pump or impeller, driven by the turbine itself. The faster this pump was driven the greater the pressure which it generated, and this pressure, balanced by a spring-loaded piston or diaphragm, was made to control the inlet mechanism.

L. C. Loewenstein, of Lynn, has recently taken out, and assigned to the General Electric Co., a patent for the device shown in the accompanying engraving. *AA* is the impeller which receives oil at its center and delivers it at its circumference under a pressure dependent upon the peripheral speed. The delivery port is partly covered by a bowl-shaped piece, the knife-edge rim of which is at the extreme left, inclosing the entire propeller when the throttle is entirely open. As the pressure increases, and the diaphragm is pushed back, the bowl-shaped piece is retired with it, cutting off more and more of the fluid delivered by the impeller from acting upon the diaphragm. An increase in speed, therefore, not only increases the pressure which acts on the diaphragm, but forces the bowl-shaped regulator in the same direction and at once decreases the quantity of oil delivered against the diaphragm, which relieves the pressure and prevents the diaphragm from compressing the spring to excess. This overcomes any tendency of the governor to hunt and renders it more sensitive and accurate in operation, the governing being limited to only a short range of deflection of the diaphragm.



CENTRIFUGAL GOVERNOR FOR STEAM TURBINE

Increasing Output of Gas Engines

SYNOPSIS—Description of a method employed by Ehrhardt & Sehmer for increasing the output of their engines. The burnt gases are first scavenged and the working charge then admitted under pressure, thus increasing the weight of the charge and consequently raising the mean effective pressure.

The output of a gas engine (other things being equal) is dependent on the temperature and pressure of the working charge taken into the cylinder. In two-stroke-cycle engines, the good influence through a reduction in temperature by scavenging the burnt gas with cold air is well known. It is obvious that in four-stroke-cycle engines a similar advantage can be gained by scavenging.

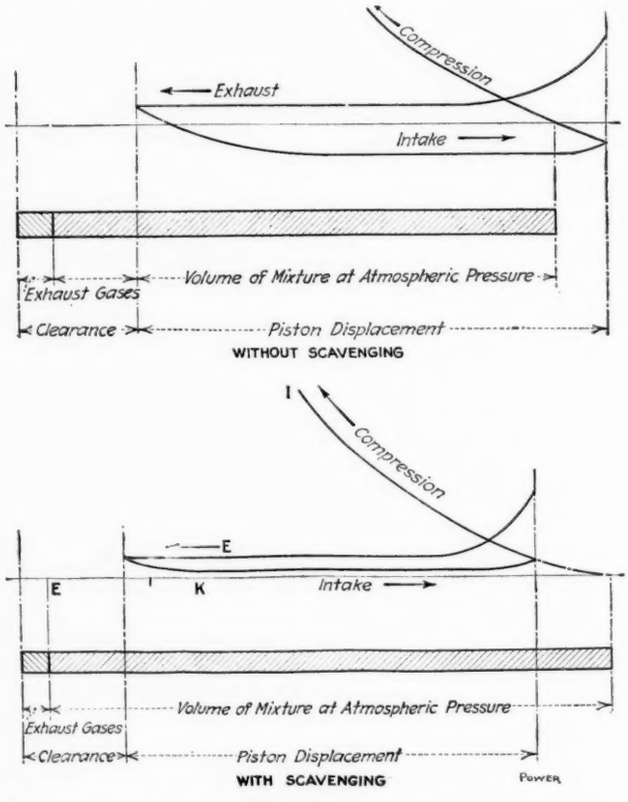


FIG. 1. STOP DIAGRAMS ILLUSTRATING GREATER CHARGE WITH SCAVENGING

Lowering the inlet gas temperature by this means makes possible an increased weight of charge and also fills the compression space with working material instead of partly with burnt gases; see Fig. 1. Furthermore, through the scavenging of the waste gases, the burning power of the mixture is increased and a sharper ignition is obtained.

Four-stroke-cycle engines with scavenging of this nature have been on the market for several years in England, and in Germany a similar method has been tried on large engines. Further steps have been taken by Messrs. Ehrhardt & Sehmer, of Saarbrucken, Germany, by combining the scavenging process with increased pressure of the charge, and the results up to the present indicate a wide field of application, as it appears that the economy is raised as well as the output increased and the working conditions improved.

In this new method the charge is placed under a pressure of 10 to 15 lb., and a steady flow is attained by passing both the gas and air through a turbo-blower. Before the exhaust stroke is finished, and just before the exhaust valves are closed, the inlet valve for the air under pressure opens and the compression space is scavenged free from burnt gases. When the piston passes dead center, the exhaust valve closes, the inlet valve opens wider, and at the same time the gas valve also opens; thus both air and gas under pressure flow together into the cylinder. The mixture is compressed up to from 90 to 120 lb. and ignition takes place in the usual manner.

The increased output which results is due essentially to the increased weight of charge brought about by the economical use of the compression spaces by introducing the mixture under pressure. The blowers which supply the air and gas under pressure are driven either by electric motors or steam turbines, the power consump-

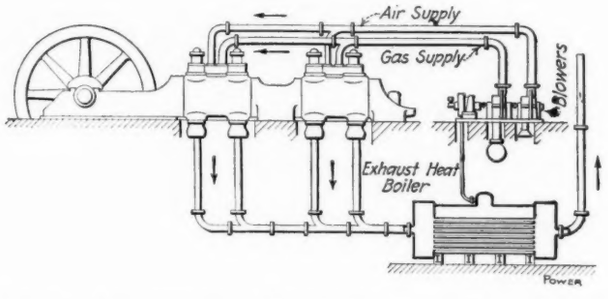


FIG. 2. ARRANGEMENT WHEREBY BLOWERS ARE DRIVEN BY TURBINE SUPPLIED FROM EXHAUST-HEAT BOILER

tion being from 6 to 7 per cent. of the engine output. Against this power consumption must be reckoned the work of suction of the normal four-stroke-cycle engine, while due regard must be paid to the largely increased output.

With one arrangement the blowers are driven by steam turbines, the steam being raised in boilers heated by the exhaust gases, of the engine, as shown in Fig. 2. In this way the whole of the increased output is available for useful work without reduction.

An interesting feature of the curves shown in Fig. 3 is the almost constant value of the heat consumption between full load and about 70 per cent. full in the high-output engines, whereas in the ordinary four-stroke-cycle engines, the corresponding curve rises rapidly between these limits, showing an advantage in respect to heat consumption for the high-output method of working in stations having loads varying between three-quarters and full load.

This method involves no extra valve-gear, as will be seen by referring to Fig. 4. It is distinguished from the normal valve-gear only through the formation of the cams on the layshaft and the form of the disk valve for the closing of the gas supply. The disk valve on the inlet spindle has, compared with the normal disk

valve, a greater lap. Since the inlet and disk valves move together, the inlet valve for scavenging must open earlier than in the normal method, hence the lap must be made so large that the air valve opens earlier than the gas valve. The remainder of the valve-gear and the general construction of the engine remain unaltered.

At the Skinningrove Iron Co., Ltd., of Carlin, England, there is a plant consisting of two 25½x32 11/16-in. gas engines running at 136 r.p.m., together with three larger units having 37½-in. cylinders by 43 5/16-in. stroke and running at 109 r.p.m. These engines operate on blast-furnace gas and drive 3-phase generators. Tests on one of the larger engines showed the following results:

	Normal Working	High Output Method
Normal continuous output, b.hp.	1300	1880
Mean piston pressure, pounds per sq.in.	60	77.5
Maximum momentary output, b.hp.	1460	2055
Mean piston pressure, pounds per sq.in.	67.5	84.5

This maximum load by no means represents the possible upper limit, as it would be possible to operate the engine at a mean pressure of 95 lb. per sq.in. Before

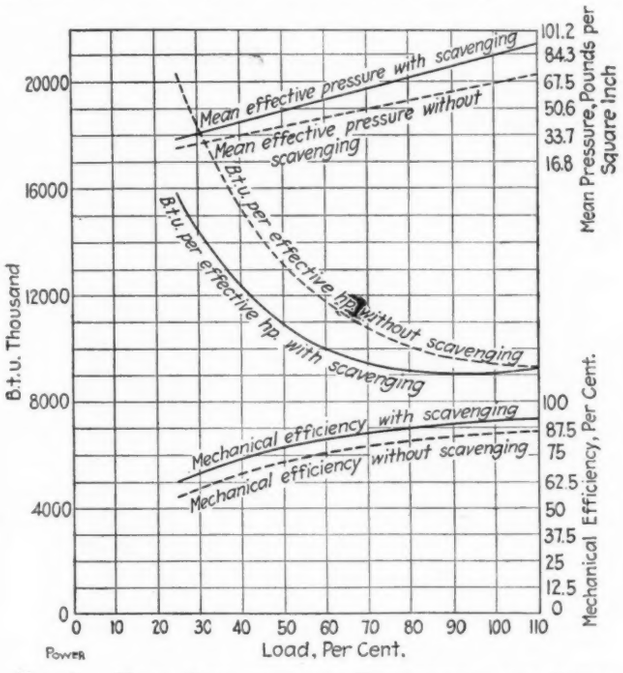


FIG. 3. HEAT CONSUMPTION, EFFICIENCY AND PRESSURE CURVES

the scavenging plant was put into operation, it was necessary for two engines of 800 hp. and two of 1400 hp. to run in parallel. Since the high-output method has been adopted, it has been found possible for the two 1400-hp. engines alone to deal with the load requirements, so that the smaller engines stand as spares.

In the central station of the Rochling'schen Eisen und Stahlwerke at Voelkingen there are installed two gas engines having 45¼-in. cylinders by 51 3/16-in. stroke and running at 94 r.p.m. They operate on the Ehrhardt & Schmer system with blast-furnace gas and drive direct-current generators. The following shows some of the results obtained:

	Normal Working	High Output Method
Mean load, kilowatts	1,318	1,830
Maximum load, kilowatts	1,570	2,140
Mean energy production in 12 hours, kilowatt-hours	14,300	19,950
Maximum energy in 12 hours, kilowatt-hours	15,270	20,940

The large overload capacity of this type of gas engine makes it adaptable to rolling-mill work inasmuch as such engines must operate with strongly fluctuating loads. An advantage is found also with this new method in power houses located at a considerable height above sea level. It is known that with gas engines operating under such conditions, the loss in output is about 1 per cent. for every 300 ft. above sea level. Such loss, however, can by the high-output method be diminished by correspondingly varying the gas and air blowers.

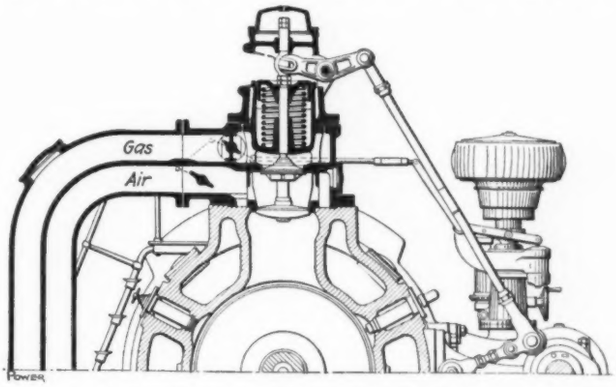


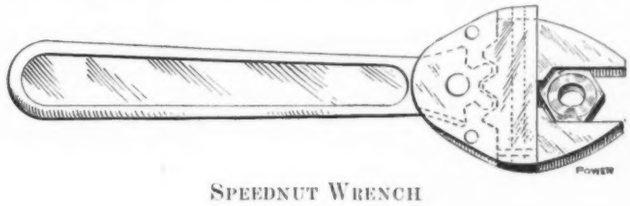
FIG. 4. VALVE-GEAR OF EHRHARDT & SEHMER ENGINE

The manufacturers are said to be building engines of this description in sizes up to 5500-kw. capacity.

Cochran Speednut Wrench

A wrench that has no thumb-screw adjustment, and is capable of gripping a nut from ¼ to ¾ in. in size is illustrated herewith.

It has only three parts. One jaw is fixed and is a part of the head in which the other jaw slides. The sliding



SPEEDNUT WRENCH

jaw has a rack which engages with teeth formed at the end of the pivoted wrench handle, so that the harder the pull, the tighter the grip.

The wrench is made by the Cochran Pipe Wrench Manufacturing Co., 7800 Woodlawn Ave., Chicago, Ill.

Water in Exchange for Refuse—Milwaukee has a refuse incinerator with a total capacity of 300 tons a day. A 6000-kw.-hr. turbo-generator is driven by the steam raised in a 200-hp. boiler. The current from the generator is to be transmitted to a flushing-tunnel pumping station, some two miles distant, which will pump lake water into the north end of the Milwaukee River for flushing and cleaning purposes.

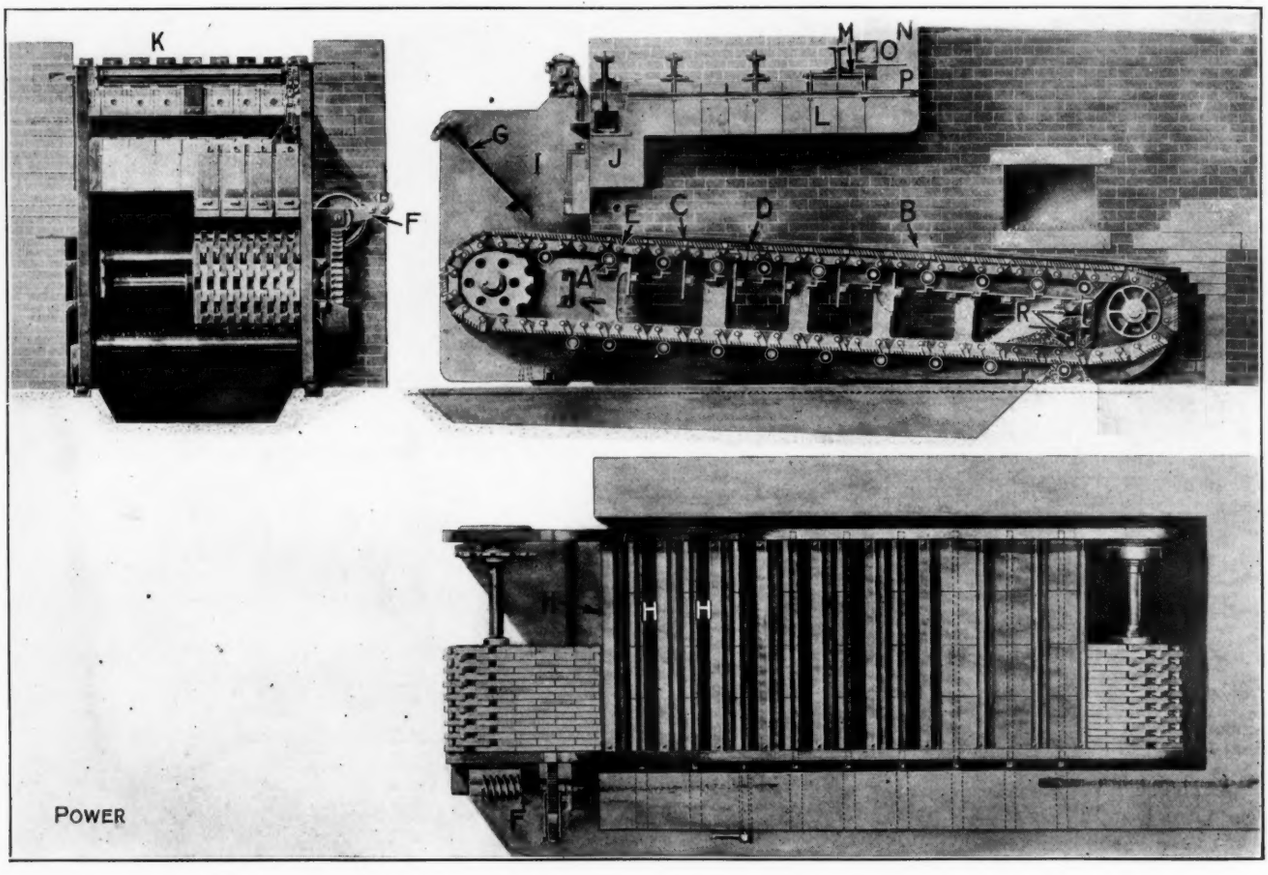
Texas Coal Production in 1913—The state of Texas mined 2,429,144 short tons of coal in 1913, valued at $4,288,920, according to E. W. Parker, of the United States Geological Survey. This production was nearly evenly divided between lignite and bituminous coal, with the balance slightly in favor of the latter. Both classes of coal showed increases in production in 1913, and both made their record output. The total production in 1913 exceeded that of 1912 by 240,532 short tons, or 11 per cent., in quantity, and by $633,176, or 17 per cent., in value.

Illinois Chain-Grate Stoker

In the new model of the Illinois chain-grate stoker, the side frames are connected and held at right angles to the drive shaft by front and rear cross-braces. The side frames are at right angles to the drive shaft and the carrying rollers *A*. Every second carrier is a tight roller, consisting of a pipe spreader, about which the roller revolves. The side frames are tightly drawn against these spreaders by rod bolts; in addition, diagonal braces provide means of squaring the frames. The frame is mounted on wheels and forms a self-contained unit which can be moved on rails in or out of the setting at will.

The chain is driven by sprockets keyed to a front shaft. On the rear shaft are idler drums, kept in place by set collars. Motion is imparted to the grate by means of the driving mechanism *E*. This drive consists of a ratchet and pawl and a worm and wormwheel, by which combination the grate can be run at five speeds. The principal advantage of the worm and wormwheel is that any slack in the chain can be taken up by means of bolts at the front of the stoker while it is in operation.

The coal feed can be regulated by changing the driving speed and by raising or lowering the tile-lined feed



Details of the Illinois Chain-Grate Stoker

The frame tops are protected by brickwork built up on ledge plates *B*, set flush with the line of the moving chain.

The links *C* of this chain are 9 in. long. The air slots on the opposite sides of the links, sloping in opposite directions, offer resistance to fine coal sifting through the grate without reducing the available air space, which in the standard links is 23 per cent.

Should a link in any way become broken, the grate can be repaired without delay by inserting a repair link *D*, made in two parts and having open rod holes. The halves are then slipped into place, a pin is driven through a hole cored in the head of the link, its ends are peaned into a slight depression, and the damage is repaired.

The chain rods *E* are round, with the advantage that they can turn, thus bringing all parts of the surface to wear, and there is no danger of the links becoming locked in a humped position.

gate. There are no bolts in the entire feed-gate frame to rust from coal moisture. When placing the tile it is only necessary to slip the clip on the end of the tile, hook the shoe *I* on the clip, and hang the tile, by means of the shoe, on the feed-gate frame. The shoe and tile are then secured by a small tapered pin. All parts are accessible by merely dropping the hopper plate *G*, which is held in place by a hook.

The ash baffles *R*, between the two strands of chain at the rear of the stoker, have been devised to prevent any air leakage at places where excess air would be detrimental. The air is distributed to various parts of the grate by movable dampers *H*.

When the stoker is doing half duty, enough dampers are closed to make the active grate surface just large enough to carry the load with the most economical rate of combustion. Since efficiency is proportional to fur-

nace temperature, a short hot fire, with no excess of air, is more efficient than a dead, smoldering fire carried to the end of the grate through cutting the stack draft and decreasing the rate of combustion per square foot of grate to an unprofitable figure. By opening or closing the dampers, the stoker is adaptable to all conditions from a banked fire to above 200 per cent. rating.

The design of arch affords a large combustion chamber of practically uniform cross-section its entire length. The short front arch makes it impossible for the coal to enter the furnace for a foot or more before igniting. The arch, being high at the front of the setting, allows the flame to propagate itself freely, thus raising the temperature of the short ignition arch, and also reflecting the heat where it is required for raising the temperature of the coal to its point of ignition as soon as possible after entering the furnace.

The supporting channels rest on plates in the side walls. Between the front channels, hangers are inserted to support the channels carrying the cast-iron arch brackets, which support the tile *J* by fitting into grooves in the side of the tile. This is shown on the front view of the stoker setting. Between the channels, hanger plates having holes punched in them, for receiving the pin *K* on one end, and the pipe *L* on the other end, are inserted. The rod *M* is used to avoid excessive overhang on the end portion of the pipe *L*. This construction permits of a substantial curtain wall *N*, supported by channels. Between the flanges of the channels are inserted small ⊥ section clips. Beneath the channel and resting on the cross bars of two adjacent ⊥ clips are the plates *O*. This arrangement gives a light, durable support, and permits those parts subjected to the heat to be replaced at small cost.

The firebrick-arch blocks, having holes through them, are threaded on the pipe *L*, hangers being placed at intervals not exceeding two feet. The holes in the tile are so far from the surface that all possibility of the blocks breaking, due to perforating, is obviated. Any width of arch is made up by placing the required number of these independently suspended sections side by side.

As the rear tile is generally subjected to the most severe usage, provision has been made for renewing this block. The cast-iron plug *P* is inserted in the ends of the pipe, and in the event that the tile and supporting plug are burned off, all that is necessary to replace this end member is to remove the old tile and plug and put new ones in their places. This often saves the expense of a whole new arch. The plug *P* has a hole through the center which permits a small amount of air to be drawn into the furnace and keeps the suspension cool. Since the air is preheated in passing through the tile it is a benefit rather than a detriment to high furnace efficiency.

To enable the fireman to watch the furnace condition closely, inspection doors are provided and, with the above mentioned means of regulation at his command, he can closely approximate ideal conditions.

Will Quizz, Jr.

SYNOPSIS—Quizz is disgusted with a mechanical engineers' handbook because the pulleys he figured by its rule did not give the right speed to the pump. Chief Teller gives him a word about "horse sense."

"There, ding it! Chief, I did it by the rule, and it's wrong."

"Oh, now don't get all het up, Will; there's a limit to the application of almost every rule. You have to know something—even if it be only hoss sense—in order to use handbooks."

"Yes, but a rule is a rule, and this one is a simple $2 \times 2 = 4$ tabloid. I wanted to belt that old pump to the blower shaft. It takes 84 r.p.m. of the pump to give the water we need, and the blower makes 150; what should be the diameters of the pulleys?"

"What does the rule say, Will?"

"Why, 'multiply the diameter of the driven pulley by its speed, and divide by the speed of the driver.' I got a 25-in. pulley with a 6-in. face from the storage room and put it on the pump. Then I used the rule to calculate the size of the pulley for the blower shaft. Thus,

$$\frac{25 \times 84}{150} = 14 \textit{ inches}$$"

"What speed do you get?"

"Just about 80. The pump doesn't keep up to 84. I'll throw that handbook into the furnace."

"It'll make more B.t.u. by burning it in your mental dutch oven. There are two reasons for the pump losing four revolutions. You did not allow for the slip of the belt. Also, if you are as particular as the merchant who bought one million pins and complained to the wholesaler that there were three pins short, then take into account the thickness of the belt."

"The book does not say anything about the slip or thickness of the belt, and I don't know how to figure it. Show me, Chief."

"Your test shows the slip to be about 5 per cent. of the pump speed. Just figure for about that much extra and use a 14¾-in. pulley and you'll get 84 r.p.m. and better. The figuring would be like this:

$$84 \div (100 - 0.05) = 88.4$$

and

$$\frac{88.4 \times 25}{150} = 14.73$$

or a 14¾-in. pulley for the driver. A pump, like a watch, is better a little fast than slow. The thickness of the belt does not affect the relative rotative speed when both pulleys are of the same diameter, but the greater the difference in their diameters the more influence it will have. The rule is, 'add to the diameter of each pulley one thickness of the belt,' and proceed as shown. Try a few calculations, Will, using extremes in belt thickness and pulley ratios."

Engineering Phases of the Pittsburgh Smoke Problem

SYNOPSIS—A digest of the Mellon Institute's latest report with comments.

It is interesting to read the latest report of the Mellon Institute of Industrial Research and School of Specific Industries on the Engineering Phases of Pittsburgh's Smoke Problem. It clearly shows that, outside of the topography favorable to the smoke nuisance, Pittsburgh's smoke difficulty is due chiefly to carelessness in the operation of boiler furnaces.

Pittsburgh Center of Greatest Coal Field

Pitsburgh is the center of one of the greatest soft-coal fields in the world; this coal is highly volatile and, unfortunately from the viewpoint of smoke abatement, the district bring out the fact—not to be wondered at when the consumption is considered—that it is very much greater than for cities like London, Leeds and Glasgow, the annual fall being 1031 tons per square mile to 539 for Leeds, 426 for London and 820 for Glasgow.

The district is on the point of land where the Allegheny and Monongahela rivers join the Ohio. With hills on nearly all sides, with fogs and north and northwest winds to drive the smoke into the business and residential sections, there is every natural barrier to prevent the diffusion of the smoke after it gets into the atmosphere.

Poor Furnace Conditions in Business Section

In no part of the city is smoke a greater nuisance than in the business section and its immediate vicinity; and

TABLE IX. SUMMARY OF PLANT SURVEY WITH SMOKE RECORDS

							Nature of Load (1)		Smoke Records		
Fired by	Number of Plants	Fuel	Thickness of Fire	Number of Boilers per Plant	Boiler Hp. per Plant	Type of Boiler	Uniform	Variable	Number of Stacks	Per Cent. of Black Smoke	Smoke Equal to or Greater Than 60% Black (2) Min.	Stack Clean Min
Hand	56	54 P'gh coal 1 Low volatile	3" to 24"	1 to 10	20 to	*32 Horizontal return tubular			51	Average per hr. 23.4 Maximum 66.0 Minimum 0.3	Average per hr. 12.2 Maximum 40.8 Minimum 0.0	29.8 52.8 0.0
		1 Wood			2500	†18 Water tube, 3 locomotive, 3 two flue	30		11	Average per hr. 13.6 Maximum 25.0 Minimum 4.8	Average per hr. 5.2 Maximum 13.5 Minimum 1.0	34.5 48.5 18.8
Chain-grate stoker	33	33 P'gh coal slack or nut and slack in 23 plants, run of mine in 10	4" to 8"	1 to 26	250 to 6500	All water tube 23 horizontal type 10 vertical type.	8		36	Average per hr. 10.5 Maximum 51.0 Minimum 0.0	Average per hr. 2.1 Maximum 27.0 Minimum 0.0	37.6 60.0 0.0
Front feed avalanche type of stoker	34	33 P'gh coal slack, nut and slack, or run of mine and slack in 21 plants, crushed run of mine or nut size in 13	3" to 24"	2 to 22	450 to 7980	All water tube horizontal type in most cases	8	26	60	Average per hr. 27.2 Maximum 63.0 Minimum 1.1	Average per hr. 14.6 Maximum 57.5 Minimum 0.0	22.8 57.0 0.0
Side-feed stoker	19	P'gh coal in 13 plants. Youghiogheny in 1 plant. Slack or nut and slack size fuel used in 13 plants. Run of mine in 1 plant.	2½" to 12"	1 to 20	150 to 10,000	3 Horizontal return tubular 15 water tube, 1 fire tube	4	10	21	Average per hr. 7.6 Maximum 29.0 Minimum 1	Average per hr. 1.9 Maximum 9.0 Minimum 0.0	43.8 60.0 10.75
Under-feed stoker	10	P'gh coal in 9 plants. New York and Cleveland. Gas coal in 1 plant. Slack or nut and slack used in 9 plants and run of mine in 1 plant.	4" to 30"	1 to 12	85 to 1200	4 Horizontal return tubular 5 water tube 1 Scotch marine	4	6	12	Average per hr. 6.5 Maximum 15.0 Minimum 0.0	Average per hr. 1.35 Maximum 13.0 Minimum 0.0	43.1 59.8 10.8

Remarks:—*These stacks are connected to boilers without fire tile roofs or coking arches over the fire. †Boilers are equipped with Dutch ovens and with coking arches greater than 2'6" in length over the fire. 1. In a number of cases information on the nature of the load was not obtained. 2. An average of eight minutes per hour of smoke equal to or greater than 60% black constitutes a violation of the city smoke ordinance.

is cheap. Added to this is the fact that the industries of the city make the plants large users of coal. The figures of Mr. Searle, chief smoke inspector for the city, show that in 1912 the Pittsburgh district consumed 17,721,783 tons, making it the largest consumer of bituminous coal in the world. In addition, it uses five million tons of coke, but coke, however, is not a smoke producer. With such an enormous consumption and with the price of fuel so low, the natural tendency is to hire cheap labor in the boiler room and ignore the use of equipment conducive to economical and practically smokeless combustion.

Enormous Soot Fall

Careful tests to determine the amount of soot fall in unfortunately that district produces, according to the report, nearly all of the smoke in that section.

The reasons are that the boiler rooms of the office, store and public buildings are usually cramped and crowded, having furnaces of inadequate volumes, tortuous flues and stacks and are dark and illy ventilated, thus offering inducements to negligence by the firemen. Investigators of the smoke problems of cities know that while Pittsburgh is not alone in this, the extreme conditions surely offer a convincing reason for the necessity of compulsory engineering supervision of plans and specifications for new and remodeled furnaces and flues. These preventable conditions are also true of the manufacturing territory, which produces most of the smoke made in the

district. Of the stationary plants investigated, it was shown that at least a 30 per cent. decrease in fuel consumption could be effected by changes in furnace construction and firing methods.

What a field for the combustion engineer if the price of fuel were high or the plant owners should suddenly be filled with enough civic pride to provoke enthusiasm in combating the smoke evil!

The Merits of Firing Methods

In discussing hand firing, the report contends that neither the alternate nor coking methods can be made to produce as good results with a vertically as with a horizontally baffled water-tube boiler, because with the former the gases from the green coal immediately rise from the fire into the cooler volume above, while with the horizontal baffling, these gases must pass between the incandescent part of the fuel bed and the refractory fire tile on the bottom row of tubes.

The Chicago Method Good

As only the spreading, alternate and coking methods are discussed, one concludes that a combination of the spreading and coking method, so favorable in hand-fired plants in Chicago, was not tried.

Illinois coal, generally used in Chicago, is higher in volatile matter than Pittsburgh coal and the method of firing as recommended by Mr. Monnett, chief smoke inspector for Chicago, should be productive of as good results in Pittsburgh as in Chicago. The method is to charge the furnace by throwing coal in small piles distributed over the fuel bed. When the volatile has been driven off the piles are leveled.

This is a compromise between all three methods, spreading, alternate and coking, that will, to an appreciable extent, overcome the disadvantages of each of these methods. It is conceded that the spreading method is invariably bad; distillation is so rapid with the alternate method that more or less dense smoke is produced for short intervals after each firing; with the coking method, distillation is slow while the coal is in a pile at the front of the grate, but, when pushed back on the incandescent fuel, is so rapid as to make black smoke, the amount depending upon the quantity of coal pushed back and on its volatile content. With what may be called the Chicago method, the coal to be coked is in small piles on the incandescent bed instead of in one large pile on the front of the grate. Distillation is complete and slow enough from the piles so that while coking and when spread over the grate, a large volume of black smoke is not produced. Like other methods, this entails extra effort, but if one wants smokeless combustion with hand firing, he has got to work for it. Pittsburgh might do well to try this method.

Longer Ignition Arches Needed

The report pleads for long ignition arches and favors horizontal baffles. This may be best for all furnaces using Pittsburgh coal, and for furnace using any coal, providing there is sufficient furnace volume obtained by a high setting. The writer has observed that, with ordinarily high settings, boilers horizontally baffled and burning some Eastern bituminous coals have failed utterly to operate at even rated capacity because the furnace temperature was so high as to quickly fuse much of the ash and decrease the air supply by plugging the grate. By changing to vertical baffling or getting a coal with ash that has a much higher fusing point, or exposing the bottom row of tubes, the trouble ceases. Fortunately, most coals do not give much serious trouble in boilers so baffled.

Handfiring Better Than Frontfeed Stoker

The accompanying table, which is a summary of the surveys of 152 plants, shows the surprising fact that the front-feed-overfeed stoker gives poorer results than hand firing, so far as smokelessness is concerned. Thirty-four plants having these stokers under horizontal water-tube boilers, and all except one using Pittsburgh coal, produce smoke equal to or greater than 60 per cent. black (Ringlemann) for an average of 14.6 minutes per hour against 12.2 minutes for 32 hand-fired horizontal return-tubular boilers, while with 18 hand-fired water-tube boilers, the average was 5.2 minutes per hour. Notice that the hand-fired tubular boilers do not have coking arches or dutch ovens as is the case with the hand-fired water-tube boilers.

The reason for the poor results with these stokers, as compared with hand firing and other stokers is, perhaps, due to two chief causes, namely too frequent disturbance of the fire by hand and too short ignition arches placed too near the grate. The last defect may induce the first, for under such conditions the green coal does not coke sufficiently on the dead plate, but volatilizes so rapidly when it gets further down that black smoke is produced. This, with some coals at least, leads to clinker troubles that cause the firemen to disturb the fire frequently, often provoking the trouble.

Locomotive Smoke

Locomotives contribute the second greatest amount of smoke in the district. This smoke is exceedingly objectionable because the stack is so low that the smoke quickly diffuses over a comparatively wide area before it has risen much above the height of the stack. The conclusion is reached that the electrification of yard locomotives especially will be necessary before the ultimate solution of the railroad smoke problem is made.

Mechanical stokers assist in considerably reducing the smoke produced in metallurgical furnaces.

Smoke from boats in the rivers adds comparatively little to the smoke of the district.

Long Transmission Span—On the long line of the Mississippi River power Co. is a span 200 ft. at the crossing of the Missouri River. The conductor at this point consists of ⅝-in. stranded steel core overlaid with 20 strands of No. 10 B. & S. hard drawn copper wire. The normal sag is about 150 ft.

Available Water Power of Ontario—Ontario has many inland lakes, of which the two largest are the Lake of the Woods, with an area of 1851, and Lake Nipigon, with 1730 square miles. The ten most important of these lakes have a total area of 6128 square miles. The numerous rivers and lakes scattered throughout the province, particularly in northern Ontario, afford almost unlimited water power. It is estimated that the total available water powers of the province are sufficient to produce between 4,000,000 and 5,000,000 hp., of which about 1,000,000 hp. had been developed in 1910. It is proposed to retain in the hands of the government as far as possible these immense waterpowers to be developed as needed for the benefit of the people and not for the enrichment of private monopolies.

Massachusetts Boiler Law and Rules--III

By C. J. Andrews

SYNOPSIS—This is the concluding installment of the analytical discussion of the rules drawn by the Massachusetts Board of Boiler Rules.

Section 4 (continued)

Paragraph 36 permits tested stay-bolt material to be used at a factor of safety of 6.5. This does not appreciably increase the allowable load, except for the smaller sizes of steel stays.

Paragraphs 37, 38 and 39 contain useful and convenient tables, well worth embodying in other rules of the kind.

Paragraph 43 specifies how rivet holes are to be made. The method given is probably as safe and good as drilling the holes from the solid plate, but the latter is practically as cheap and so specifying would relieve the shop inspector from keeping a record of the size holes punched on every boiler to show that the rules were complied with. Often an inspector sees only the finished hole and it is impossible for him to tell whether the required amount of metal has been drilled out or not.

Paragraph 46 requires the calking edge of the plates to be beveled wherever possible. This rule should add that such beveling be done on a planer and not on bevel shears, since shears probably injure the metal as much as punching rivet holes full size.

Paragraph 47 specifies the method of making tube holes. A limit placed on the difference to be permitted between the diameter of tube holes and that of the tubes to be expanded in them would have improved the rule and the boiler's safety.

Paragraphs 49, 50 and 51, dealing with the manner of finishing the tube ends for both fire-tube and water-tube boilers, are very important, both from the standpoint of safety and to obtain good workmanship.

Paragraph 53, giving the minimum number of pipe threads in an opening, is also important. It should, however, be modified to permit of some fittings being bolted to a boiler. The rigid enforcement of the rule as it now stands would cause the rejection of some perfectly good and safe construction, which is even better than riveting the parts together.

Paragraph 56 specifies the material for manhole frames. A number of failures have occurred at this point in the past; similar rules should be made by others.

Paragraph 59 concerns the material for manhole plates. While plates conforming to these specifications may be made lighter than cast-iron plates, still cast-iron is perfectly safe for such use and should not be barred.

Paragraph 60 requires a manhole located in the front head below the tubes, in a boiler 60 in. in diameter or over. There has been considerable criticism of this rule on account of this requirement, due to the fact that, in New England, the feed water is of exceptional purity, and it has been customary to place only handholes below the tubes and some of the New England boilermakers objected to changing this practice. In other sections, the conditions are quite different and it is necessary to have a manhole below the tubes to afford access for cleaning.

Ohio rules specify that manholes must be placed below the tubes in all boilers 48 in. or more in diameter. This is the safest plan to be adopted by others because the manhole can do no harm and at times is a necessity.

Paragraph 62 requires a handhole in the rear head below the tubes, in all boilers not having a manhole below the tubes. Such hand-holes are so troublesome that the wisdom of this rule is doubtful. They greatly facilitate cleaning, but have also been the means of ruining many boilers. All boilers of this type should have manholes below the tubes, except those of very small diameter, extra-wide spacing between the center tubes and ample space between the shell and tubes at the side would avoid the necessity of having handholes in the rear heads below the tubes.

Paragraph 66 requires at least 1 in. of solid metal, in the clear, around a handhole opening, except where the plate is $\frac{7}{16}$ in. thick or over, when the prescribed amount is reduced to $\frac{1}{2}$ in. The only good reason for this rule seems to be that plenty of metal to work on makes repairs easier where corrosion has eaten away the metal below a handhole opening on a vertical or locomotive-type boiler. However, if this is its purpose, there is no logic in reducing the allowance in the case of the thicker plates.

Paragraphs 67, 68, 69 and 70 specify that boilers over 78 in. in diameter be supported by hangers and columns, independent of the setting walls. This rule has been criticized some, but is good and might even make the minimum size 72 in.

The reduced shearing strength allowed on rivets that attach lugs and brackets to boiler shells is justified. There should be a rule regarding the design of the lugs and brackets, so that the load on the rivets is evenly distributed. A lug may have plenty of rivets, if all were in service, so that the stress per rivet would be low, but if the design is such that only two or three rivets act together, the stress per rivet may be dangerously high. A reasonable stress per rivet is also necessary, because the stress is transmitted directly to the shell in such a way that it is added to the tensile stress on the shell, produced by internal pressure. Probably many explosions of horizontal return-tubular boilers are due to abnormal stresses in the vicinity of the supporting lugs.

Paragraph 71 makes it necessary to have the top of the grates above the leg ring in locomotive and vertical tubular boilers. This is a good rule.

Section 5

Paragraph 1 of this section prohibits a safety valve being connected to an internal pipe placed in the steam space of the boiler. This rule would be more definite, if stated about as follows: A dry pipe, or other internal device, must not be attached to a steam outlet to which safety valves are attached.

Paragraph 2 specifies that safety valves for superheaters must be placed at or near the steam inlet, whereas they should be placed at or near the steam outlet, to properly protect the superheater from overheating. The State of Wisconsin so specifies the location in its proposed rules.

Paragraph 3 requires all boiler connections over 2 in. in diameter, except the safety-valve connection, to have a stop valve near the boiler, which must be of the outside screw and yoke type. This is a good rule, intended to promote safety and should be copied.

Paragraph 5 requires two stop valves on all boilers set in a battery when a pressure greater than 135 lb. is allowed on any of the boilers. This rule deserves a place in all rules to promote safety, but the highest pressure allowed, without two valves, should be 25 lb. and the rule should read: "Where two or more boilers are connected to the same steam-pipe system, two stop valves, etc." A rule should require suitable locks and chains, for the blowoff and main steam valves, so that they may be locked closed on each boiler undergoing repairs, cleaning or inspection. Fatal accidents, caused by turning hot water or steam into idle boilers, are frequently occurring and a strict rule of this kind would tend to reduce the number of such accidents.

Paragraph 6 gives the minimum number of threads that a pipe or nipple must screw into a fitting. This is a good rule, for it avoids any controversy between the inspector and the owner.

Paragraph 7 provides two stop valves on boilers set in a battery and superheating the steam more than 80 deg. Specifying double valves, as has been previously recommended, would cover this case.

Paragraph 8 specifies that, when a globe valve is used on the feed line to a boiler, the inlet shall be under the disk. This protects against the valve coming loose from the stem and closing off the feed.

Paragraph 9 requires the feed water to be discharged about three-fifths the length of the boiler from the front head, except when a boiler has an auxiliary feed-water heating device. It is open to question whether this location can be considered the best.

Paragraph 10 seems to fully cover the situation in regard to the proper point for the discharge of the feed water.

Paragraph 12 pertains to means of feeding a boiler of over 50-hp. capacity. The rules are rather weak in this particular, for, as already pointed out in discussing Part II of the rules, the only need is that some means be provided to feed the boiler against the maximum pressure allowed; where the local water-supply pressure is high, a connection to the system may be the only means used to feed the boilers. If a boiler user should decide to have a reserve pump or injector as an additional safeguard, he would have to put in two such devices, to comply with the law, although he could leave off both without violating it. A better rule would be about as follows: "When boilers are to be operated at a pressure greater than 25 lb., they shall have two or more means of feeding, each capable of delivering an amount of water corresponding to at least twice the maximum rated boiler capacity, against the maximum pressure allowed, except in plants having three or more boilers where a reserve feeding apparatus 50 per cent. in excess of the rated capacity of the plant, will be considered sufficient. When the water supply for a boiler may be drawn directly from a water system, and the average water pressure is 20 per cent. greater, at the connection to the boiler than the steam pressure allowed, the water system will be considered as one of the methods of feeding the boilers."

Paragraph 13 requires the temperature of the feed water entering a boiler to be not less than 120 deg., when the pressure allowed exceeds 25 lb. This is a good rule and should be copied by others.

Paragraph 14 limits the maximum size of a surface blowoff to 1½ in. This does not interfere seriously with the use of a blowoff of this description. Still, there seems no reason why a surface blowoff should not be permitted as large as a bottom blowoff connection.

Paragraph 15 prescribes the sizes for bottom blow-off connections from 1 in. to 2½ in., and these are good limits to be followed. A globe valve on a blowoff connection is prohibited, which is also wise.

Paragraphs 16, 17, 18, 19 and 20 all relate to blowoff equipment and are all good.

Paragraphs 22 to 26, inclusive, deal with the water-column equipment and are good, except that, if valves had been entirely prohibited on the water-column connecting pipes, instead of requiring that they be locked or sealed open, the safety of operation would have been increased.

Paragraph 29 states that steam reservoirs are required on mains where heavy pulsations cause vibrations of a steam pipe. This rule should specify the size of reservoirs required, for, in its present form, it is of no value whatever, and it is doubtful if it could be enforced.

Section 6

Section 6 deals entirely with installations that are not standard or that were in the state at the time of the passage of the law. It is, of course, impossible to make a set of boiler rules as complete as those of Massachusetts and expect that every boiler that is made, or comes into the state, will be constructed in exact accordance with them. It was soon found that a number of boilers came into the state that did not comply fully with the rules. This was not on account of any attempt on the part of the manufacturer or owner to evade the law and it was recognized that some way should be provided, so that these boilers might be used, therefore *Paragraph 1* of Section 6, in a little different form from that now used, was added to the rules.

This paragraph provides that when an owner, or prospective owner, of a boiler that does not comply with the rules, desires, he may apply to the board of boiler rules for a permit and that such a boiler may be installed after an inspection by a member of the state boiler-inspection department. The lowest factor of safety that may be used in fixing the pressure on such a boiler is 5.5, and the longitudinal joints must conform to the requirements as given in the rules. Some provision of a similar character should be made in every law, but care must be exercised that all such boilers are penalized, for unless this is done, too many such boilers will be submitted for consideration.

Paragraph 2 provides for the reinstallation of boilers that were in the state at one time, and later removed. Under such conditions a certificate may be issued after an inspection by a state inspector or one holding a certificate as an inspector of boilers for the state. This was an-

other provision, to prevent interference with property rights.

Additions to the Rules That Might Have Good Effect

The Massachusetts rules could be materially reduced in number, for many are not directly concerned with safety. Also a number of rules might be added to advantage, besides those that have been mentioned in this discussion. For example, there are no rules to govern the construction of domes for boilers, although the rules do not prohibit their use. The Board of Boiler Rules would have been justified, if it had prohibited the use of domes on all boilers built for use in the state after the passage of the law. Unless a boiler dome is properly designed, especially with respect to its attachment, the shell of the boiler is likely to be dangerously weakened. This has led to many serious boiler explosions.

As already mentioned, the rules do not cover furnace design, where other than staybolted furnaces are used and this is very important. Some rule should be adopted to permit a limited amount of pressure on the heads of boilers and similar surfaces, without requiring that they be braced.

A rule which would reduce one class of accidents, would specify how the discharge end of blowoff pipes must be arranged. Another provision, that would tend to safeguard lives, would be that the fire-doors of water-tube boilers open inwardly or at least have substantial latches, so that the attendants would be exposed to danger from tube failures only while the fire-doors were being used.

A good rule would require the pipe connecting the steam gage to a boiler to be at least ½ in. in size and of brass up to the point where it is connected to the water-column piping or the boiler. A number of explosions have been traced to the combination of a defective safety valve and a defective gage; often the trouble with the gage has been that the connection to the boiler has been stopped with rust scale. Sometimes little time is required for a ¼-in. iron pipe to become completely stopped.

Safety valves should be required to be equipped with means to permit of their being tested from the engine-room floor. The top of a boiler is a disagreeable place, especially in summer, and only by providing reasonable means for testing valves, can it be expected that this duty will be attended to. A rule fixing a minimum height for the space over boilers would be quite desirable.

A rule specifying seamless drawn tubes of heavier gage than the standard, for water-tube boilers on which high pressure is to be carried, would tend to eliminate some of the tube accidents that are now frequent. A rule requiring that gage glasses be properly protected, would tend to safeguard the eyesight or life of plant operatives, for the breaking of a gage glass has been the cause for the loss of life.

Conclusion

In conclusion, it may be again repeated, on account of its importance, that rules to govern boilers already in service, should be given the most careful consideration, because it is these rules that will meet the opposition of steam users and if they are not strictly just, or necessary for safety, they will not stand the test of public opinion.

Nashville Rules for Heating Boilers

The department of smoke inspection of Nashville, Tenn., has adopted the following rules prescribing the quality of fuel, style of furnace, and sizes of stacks for heating boilers:

1. In all firebox boilers up to 1500 sq.ft. capacity, coke or coal with less than 20% volatile matter must be used.

2. All firebox boilers above 1500 sq.ft. rated capacity must be provided with downdraft furnaces.

Stack Sizes

3. The least dimensions allowed for stacks of boilers of various sizes are as follows:

Square Feet of Boiler-Heating Surface	Stack Sizes
Up to 500 sq.ft.	9 in. x 9 in. x 40 ft.
500 to 1,000 sq.ft.	12 in. x 12 in. x 45 ft.
1,000 to 1,500 sq.ft.	12 in. x 12 in. x 50 ft.
1,500 to 2,500 sq.ft.	16 in. x 16 in. x 60 ft.
2,500 to 3,000 sq.ft.	20 in. x 20 in. x 60 ft.
3,000 to 3,500 sq.ft.	20 in. x 20 in. x 65 ft.
3,500 to 3,800 sq.ft.	20 in. x 20 in. x 70 ft.
3,800 to 4,200 sq.ft.	20 in. x 20 in. x 75 ft.
4,200 to 6,500 sq.ft.	24 in. x 24 in. x 75 ft.
6,500 to 8,750 sq.ft.	24 in. x 24 in. x 80 ft.
8,750 to 10,000 sq.ft.	28 in. x 28 in. x 80 ft.
10,000 to 10,500 sq.ft.	32 in. x 32 in. x 80 ft.
10,500 to 13,000 sq.ft.	32 in. x 32 in. x 90 ft.
13,000 to 14,000 sq.ft.	36 in. x 36 in. x 90 ft.
14,000 to 14,500 sq.ft.	36 in. x 36 in. x 95 ft.
14,500 to 15,000 sq.ft.	36 in. x 36 in. x 100 ft.

4. The above stack sizes are for boilers which are set not over 10 ft. from the stack, counting from center of stack to back of boiler, and allow for only one right-angle turn in the smoke connection; for each additional right-angle turn add 10 ft. to the height of the stack.

5. These sizes are for cases where only one boiler is connected to the stack, and where there are no openings in the stack for other purposes.

6. Where more than one boiler is used, or where other apparatus is connected to the stack, each case will be passed on separately.

7. In all cases stacks must be carried above the top-most story of the building.

8. The top of all stacks must be at least 12 ft. higher than the roof of any building within 50 ft. of the stack.

9. Every stack not directly connected must have a clean-out door at its base at least 24 in. square. A stack less than 24 in. square must have a clean-out door of the same area as the cross-sectional area of the stack.

Coal Production in North Dakota in 1913—Although the production of coal in North Dakota in 1913 was only 495,320 short tons, valued at $750,652, some interesting facts regarding the possibilities of the vast deposits which underlie the state are shown in a statement by E. W. Parker just made public by the United States Geological Survey. All the present mineral fuel produced in North Dakota is brown coal, or lignite. Considerable areas of subbituminous coal of usable quality and workable thickness are believed to underlie portions of the lignite areas, but no attempt to exploit the subbituminous coals has been made. At present the lignite is used chiefly for domestic purposes, but with proper equipment it can be used with satisfaction as a boiler fuel. A convincing example of what may be accomplished with lignite for such use is presented by the irrigation plant of the United States Reclamation Service at Williston. The lignite used here is taken from the only coal mine owned and operated by the Government. As the gas-producer and internal-combustion engines in large units come into more general use in the West, as they are rapidly doing in the East, the lignites of North Dakota will be recognized as possessing great potentialities in the settlement and economic development of the state. Experiments also show that lignite can be successfully briquetted, after which it stands transportation well and its heat value is increased 50 to 70 per cent.

Editorials

Engineering Problems in Handling Pittsburgh's Smoke

Congratulations are due the Mellon Institute of the University of Pittsburgh for its latest bulletin, "Some Engineering Phases of Pittsburgh's Smoke Problem." It is, we believe, the best report yet published on the engineering phases of the smoke problem of a city. Heretofore, most of the Institute bulletins have dealt with smoke and its relation to the damage to laundry, buildings, vegetation and its psychic effect upon individuals. Unquestionably, these bulletins have made the citizens of Pitsburgh realize that smoke is very expensive and disagreeable, but they have not excited the enthusiasm of the engineer. The present bulletin, however, is most commendable and well worth studying.

Our review and comment on page 343, suggest many interesting thoughts on the causes and abatement of the smoke evil. Of the one hundred and fifty-two plants observed, the results again confirm the ability of the underfeed type of stoker to give smokeless combustion when properly handled. It comes as a surprise that the front-feed overfeed type of stoker under water-tube boilers should have failed to be as good as hand firing with horizontal tubular boilers and quite some worse than hand-fired water-tube boilers equipped with dutch-oven furnaces or having horizontal baffling. The probable reasons for the failure are brought out in our comment.

One cannot read the report without again being reminded that plenty of available cheap fuel is sometimes an evil as well as a blessing to a large city, for as long as it is cheap, gross negligence and resulting smoke accompany its use.

We agree with the report that for the coal used, stokers should be placed in plants of three-hundred horsepower and over.

⁂

Association Educational Work

Again the season is here when engineering organizations begin their annual educational work. As much money, time and energy will be spent for this purpose, the results should equal a commensurate return on the investment.

No matter what the nature of the work may be, but particularly if the season opens with mathematics, be sure to start low enough so that the lessons are not "above the heads" of most of the members. Those in charge of educational work are usually appointed because they are better fitted than the average member. For this very reason, they must be cautious that their methods and lessons are adapted to the majority of the class; the natural tendency is to make the lessons too advanced.

In the average organization of power-plant men, the greatest good comes from the discussion that follows a lecture. Usually, the subject is so broad that the lecturer can touch on the most essential points only. While matters of detail bearing on the merits of different methods of doing a given job or operating a certain machine are most often brought up by the members, there is still far too little of this kind of discussion, and it is the very best, too.

This leads to that most delicate of problems in conducting engineering educational work, namely, overcoming timidity. Many men who need information are so timid that even the thought of getting up and asking for it during a meeting unnerves them. This is true also of many who are equipped to give information. It requires tactful and persistent effort to clear the meeting room of this dread. Where timidity is the cause for lack of discussion, the use of a question box, hung in the outer hall, where a man may drop in his question unobserved, will do much to get good questions before the meeting.

The most useful, and generally the least used accessory, is the blackboard. When a member gets up to make explanations which would be clearer if illustrated or worked out mathematically, he should be requested to "put it on the blackboard." If this occurs frequently in the meeting, it will not be long before the members will step to the blackboard without being requested.

⁂

Learning a Trade

Often a father says that his boy shall have a trade to fall back on in case he is not successful at something else. This implies that anyone can succeed at a trade who might fail as a professional man or along commercial lines.

Such an implication every workman should resent. A trade should be a stepping stone to something better at which there is still further chance of success. Of the successful manufacturers, the larger part have come up from a trade. To them a trade was a stepping stone, not a thing to fall back on. Learning a trade, if it is learned at all, is a life job. Learning enough to hold a job at a living wage for even a small family takes time that can hardly be spared by anyone who intends to take up a profession. "Better put all your eggs in one basket, and then watch the basket."

On the other hand, as a preliminary to a technical course, it is an advantage to a young man to have worked as a machinist, if he is to be a mechanical engineer, in a power plant, if he is to specialize along that line, or in a civil engineer's office, if that is the direction in which he is headed. He will get a clearer idea of what he is going to encounter, and what he will need to know, than he can by going to school first. He will find that his technical course will divide itself into two parts, things which he should comprehend and be able to work up in detail by himself later, if occasion should demand, and things which he must make his own to use as working tools every day of his professional life. In the first he can afford a few low marks, in the second he cannot. If he has had enough experience to discover what an engineer

in his line uses for tools, he will be in a position to get his engineering education first, keep his health next, and get all the cultural and collateral education that his head will carry last.

The tools of the engineer he will find in all branches to consist mostly of principles. He may not be able to comprehend principles except as he sees concrete illustrations of them around him. Educational methods are being more and more centered around the concrete illustration, but the young man must learn to think in the abstract, to divest his problems of all but the bare bones before he begins their analysis, and then to work them out, adding to them the concrete surroundings, which came with them.

The only danger to a man who uses a trade as a stepping stone to an education is that while he is working with his hands his brain may be rusting. Conventional educational programs are built around an ability to pass examinations, which are not education at all, but only a sort of exhibition of mental alertness. The fact that examinations must be passed and that they must be led up to through study of books, is something that he must not overlook, and something that will lead him to keep up his reading evenings even when he comes home tired out and better prepared for some lighter amusement.

Wisconsin Has a Boiler Code

The State of Wisconsin has a boiler code, which is administered under the Industrial Commission law of 1913, one section of which expressly authorizes the commission to fix and collect fees for the inspection of boilers, not exceeding $2 for each external inspection, and $5 for each internal inspection, per annum, and to collect fees for the inspection of elevators, not exceeding $2 semi-annually for inspection. The commission may accept inspections of boilers and elevators by qualified inspectors of insurance companies, where such boilers or elevators are insured, in which case no fee shall be charged. The commission may also accept inspections by qualified inspectors of boilers or elevators in cities of the first, second and third classes, in which case the city may collect and retain such fee for inspection as may be fixed by the commission for its own inspection.

The code which has just been issued by the Industrial Commission saw its first practical beginning in a conference of boiler maufacturers, insurance representatives, municipal inspectors, and representatives of boiler-using interests, held at the instance of the Industrial Commission of Wisconsin in the Chicago City Hall on January 5, 1912. The object of the meeting was to discuss the formation of a standard code of rules for the building and operation of boilers, together with a means of boiler inspection which should be acceptable to the commission and to all concerned. The result of the conference was the appointment by the commission of an advisory board of boiler rules with power to formulate and recommend a code of boiler rules for Wisconsin. The first result of the labor of the board was the publication of tentative boiler rules, on which a public hearing was held on October 30 of last year. The rules as now issued, and which appear upon a cursory examination to follow very closely those of Massachusetts and Ohio, are the result of that discussion. The Industrial Commission law contains a section authorizing it to investigate, ascertain and determine such reasonable classifications of persons, employments, places of employment and public buildings, as may be necessary to carry out the purposes of the act, and it would seem that under this provision the examination and licensing of those engaged in the operation of power-producing apparatus might be brought about.

Getting Out of the Rut

In engineering, as in other fields generally, there is inertia with regard to trying new things. The tendency is to "do as we did before," rather than experiment.

Modern practice, to a large extent, must be based upon past experience, but experience is responsible for a great deal of "mind laziness."

Engineers sometimes get ideas fixed in their minds which are detrimental to progress in designing for greater efficiency.

Rather than acknowledge that a certain thing would require thinking about, and probably a little ingenuity and calculation, which he is loath to give it, an engineer will discuss it with the remark, "What did we do before under similar circumstances?" or "It worked so well before, why shouldn't it do so again." All argument as to efficiency in such instances usually has the effect of leaving a bad impression in the mind of the engineer with regard to the other party in the discussion. The engineer has a good deal at his back when he has it done as before, but it is scarcely acting up to his position as engineer to be only a copier.

He takes no chances and is perfectly safe in what he does, nevertheless, unknown to himself, he does harm in stunting the growth of the mind and initiative in his subordinates.

After a few experiences of the kind, the subordinate thinks, "Well, I could improve on that, but what's the good." If he actually works his idea out, it rarely sees daylight in constructed form, and if it does it is generally to the credit of the engineer. The future of engineering depends less upon past experience than upon men who have the strength of mind to think along different channels and get out of the old ruts. It is easy traveling along the well worn ruts, and it takes courage to quit them, but it pays to be progressive even at the expense of inconvenience. If it doesn't always take the engineer to the goal he is after, it develops his character and ability at any rate.

Discussion of fresh ideas does not always mean discarding old ones ,in fact, it often brings out and emphasizes good points in them. It is, however, necessary to progress of any kind and a half an hour's discussion, even if it leads nowhere, broadens the minds of those participating in it and hence is not by any means wasted time.

So it behooves engineers in general to be very chary in the use of the expression, "What did we do before," as such an expression generally vetos all discussion.

At the time of going to press the convention of the American Boiler Manufacturers' Association is still in session, so that we are compelled to withhold the report of the interesting discussions on uniform boiler specifications until next week.

Correspondence

Operating Underfeed Stokers

During the past three years, I have operated underfeed stokers in a manufacturing plant. Therefore, I was much interested in J. C. Hawkins' article in the July 21 issue.

It was necessary during two of the three years that we carry at least 200 per cent. rating on the boilers continuously; also as our coal was being purchased from several dealers, we could not count on a uniform grade. The first few months we experienced troubles similar to those described by Mr. Hawkins. At first, we were inclined to condemn the stoker, but then it occurred to us that if it was an inherent weakness, this type could not have been adopted as standard by practically all large power plants. We first studied the design. It is quite evident that the stoker is to feed the coal in from the front and, as it burns, to slowly move it backward and downward toward the dump plates; to have it burned out to ash when it is deposited on the dump plates, and then periodically dump the ash and refuse.

Starting with no prejudices and forgetting our past experience, we failed to find any reason why the stoker could not be operated in this manner, thereby making all barring of the fire unnecessary. The problem then was to actually do it.

We soon found that our trouble had been due to our own ignorance. After making a careful study of the equipment and the necessary adjustments, we have eliminated all trouble. At one time a clinker was formed extending from one furnace wall to the other. This occurred only once and was caused by careless operation. Naturally, the first observations were made when cleaning the fire. By carefully watching the conditions and observing the clinker formation on the dump plates, and also extending beyond the dump plates up into the fire, it was believed that the clinker extending from wall to wall had been formed from the dump plates up and not by building from one wall to the opposite wall. All subsequent observations have further proved this fact.

After cleaning the fire, the fuel bed moves forward until the dump plates are covered, and the ash and refuse naturally forms into a clinker which lies directly on the dump plates. When this clinker becomes a certain thickness, it then begins to form back into the stoker proper, and if continued a sufficient length of time, the unburned fuel is deposited on top. This clinker prevents the air from penetrating through the fuel bed, and therefore the coal and coke on the clinker is not burned satisfactorily. This condition is temporarily overcome by stirring the fires with bars. As this remedy is only temporary, the use of bars again become necessary. Constant barring soon builds a thick clinker a considerable distance up into the stoker, extending from wall to wall. In addition, the barring tends to make smoke and to throw cinders. The remedy is quite obvious and simple: Clean the fire at shorter intervals, so that a clinker can form a short distance only above the dump plates.

The cycle of events is about as follows: Clean the fire by dropping the dump plates (not by barring the fire), then for a short period use a longer, lower ram stroke, thereby quickly pushing the short projection of clinker which remains above the dump plates on the dump plates. Then run under normal stroke conditions until the next cleaning period, that being when the clinker lying on the dump plate extends a short distance only beyond the plate.

By careful observations for a few days, these cleaning periods can be definitely fixed and the work will be easily and quickly accomplished. The only use for a bar is to break off any part which may stick to the bridge wall; which is infrequent. Bars are unnecessary except to clean the side walls once in twenty-four hours, and their use for other purposes leads to worse clinker troubles.

The formation of side-wall clinker is also materially decreased by operating in this manner, doubtless due to a freer motion of the fuel bed toward the rear of the stoker. If the dumping periods are fixed correctly and the right proportion of air and coals used (which is readily determined), there should be no smoke when cleaning the fires.

The results obtained by this method of operation have been most gratifying and have shown a marked increase in evaporation per pound of coal; furthermore, this is being done with scarcely any hard manual labor. Any trouble from clinkering on the tuyeres is due to faulty operation because, properly operated, there can be no condition to cause clinkers other than a slight burning of refuse, which is in no way objectionable; as a matter of fact, it forms a protection against burning a tuyere.

Small handhole openings are provided in the wind box for inspection and any small quantities of coal which might sift in can be readily cleaned out through these openings. The condition of the interior of the stoker also can be determined by periodical inspections. A large quantity of sifting indicates at once that something is probably burned in the stoker; it is not necessary to burn out the fire to determine if the interior of the stoker required repairs.

No trouble has even been experienced in carrying banked fires for a week. The method pursued is as follows: The fire is not cleaned previous to banking. When banking, the air is shut off and one hopper full of coal is fed in. The boiler damper is then closed as tightly as possible; boiler dampers never fit absolutely tight and the leak around the damper will carry out any gases formed during the banked period. One hopper of coal is usually sufficient to maintain a banked fire from thirty-six to forty hours, thereafter, a little coal is fed in from time to time. The ash is also dumped during the banked period. In starting up from the banked fire, the stoker is first dumped and then started, using the long stroke of the ram for several revolutions, before any coal is fed in the hopper, the hopper having been left empty at the time of banking.

As the load varies through wide limits, it is necessary to have a wide range of operation in the regulating mechanism. This range is cut down to as narrow limits as possible, the high speed being controlled by the governor and the low and intermediate speeds by the regulating valve. After settling on the correct time between cleaning, the result is that the fires are always clean and free from excessive ash and clinker. This has apparently brought the necessary limits of speed closer together and considerable less air pressure is now needed to carry the same load on the boilers.

There has never been any objection to cinders issuing from the stack. The cinders collected behind the bridgewall, however, have been materially decreased by narrowing the fluctuations in speed and by maintaining as low natural draft over the fire as possible without blowing fire and gases out of the furnace doors. Cinders from the stack in sufficient quantity to be objectionable are no doubt due to large amounts of ash in the fuel bed (caused by too infrequent cleaning), making high air pressure necessary to burn out the coal.

In operating any automatic stoker it must be borne in mind that the essential idea is its automatic design, and that the application of hand-fired principles is not a remedy for conditions due to improper operation.

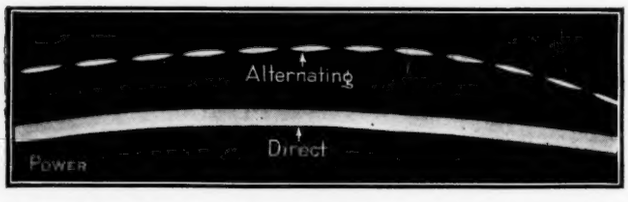
STANLEY O. LARGE.

Philadelphia, Penn.

Photographing Alternating and Direct Currents

The accompanying photographs were taken of an arc lamp of the multiple 110-volt type, the lamp being placed in a room with all other lights out. The operator then placed the camera in position against his chest and swung it rapidly in a horizontal plane with the shutter open. The relative intensity of the arc was so great as to render the image very sharp.

The upper photograph shows clearly the alternations of the alternating-current arc, the zero points of the current being represented by the breaks in the strokes. The peak is also shown at the center of each, with the ends gradually tapered. Each of the light strokes represents a complete alternation (two represent a complete cycle)



ALTERNATING AND DIRECT CURRENT AS RECORDED ON A PHOTOGRAPHIC PLATE

and the photograph shows six cycles.

The time required to photograph the 12 alternations may be easily figured. The circuit was 60 cycle and six cycles are shown, hence the time required must have been $\frac{1}{10}$ sec.

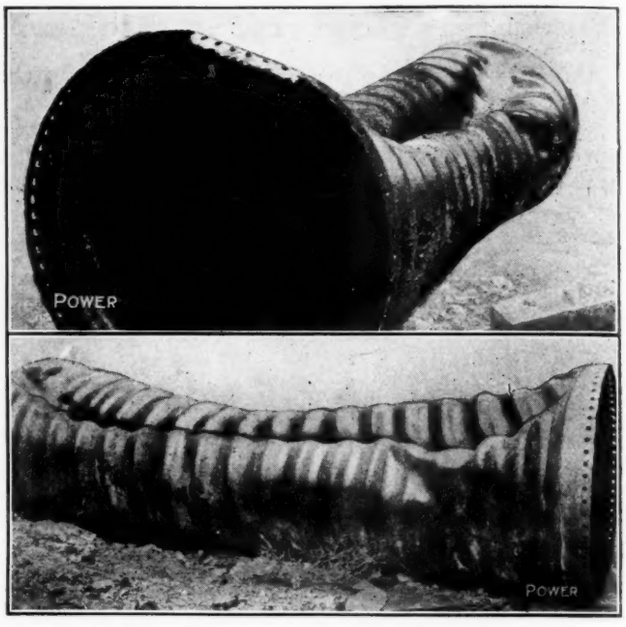
The lower view is of the same arc lamp supplied with direct current. A continuous streak of light is here shown, as would be expected, the greater width being due to a longer arc.

J. B. LINKER.

Charlotte, N. C.

Blowoff Valve Left Open

The illustrations show the condition of a corrugated furnace taken from a Scotch marine boiler in the power plant of the Utah Fuel Co., Castle Gate, Utah. After blowing down, the fireman forgot to close the blowoff valve. When next observed, the boiler was practically



FURNACE AFTER REMOVAL

dry and only the arrival of the chief prevented the introduction of cold water into it. They closed the valve in the steam takeoff to the main header and pulled the fire. When the flue was removed it was found to have a huge wrinkle the full length as shown but not a crack could be found in the metal.

RANSOM S. HAWLEY.

Ludington, Mich.

Oil Soaked Coils

A short time ago, I was called upon to dry out the electrical machinery in a small hydroelectric plant of 375 kv.-a. capacity. The alternators were three-phase, 2200-volt, 60-cycle machines one 150 kv.-a., and one 225 kv.-a. This plant is protected against high water by a high concrete wall and a large sump pump. The river rose very rapidly on this occasion, and the water came over the wall, filling the power house slowly to a point just above the bearings of the 150-kv.-a. machine, but not high enough on the other generator to float the oil out of the bearings. The lower coils of the smaller unit were soaked, and as there was no current through the building, the oil from this machine floated around it while the water receded.

On account of other damage to the plant, it was impossible to start drying out for five days after the flooding. The generators were then dried in the usual manner, by short-circuiting the armature leads and passing a heavy low-voltage current through the winding. There was no means at hand for testing the insulation resistance, and at the end of eight days the larger unit was put in service. It has given no trouble. The other ma-

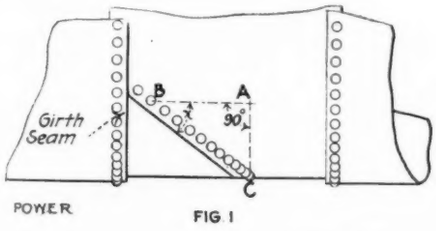
chine was kept on short-circuit run for three weeks, and then put on the line, two coils burning out after 14 hours' running. On taking the damaged coils out, they were found to be still very wet, so the machine was again short-circuited and run for another week. It was then put on the line again and one coil burned out after a twelve-hour run. Upon investigating, we found that all the coils in this machine that were submerged were wet, and that the outside layers of taping were thoroughly impregnated with the oil from the bearings, making it impossible to drive out the water which was in the inner wrappings. The wet coils were then taken out, the old tape removed and the coils dried by baking. On retaping and replacing the coils in the generator, the trouble disappeared. The lesson to be learned from this experience is, to take the oil out of the bearings before leaving the machines.

D. D. SMALLEY.

Bagby, Calif.

Calculating the Strength of Diagonal Boiler Joints*

Calculating the strength of diagonal boiler joints accurately is rather difficult, unless one is familiar with trigonometry. It is fortunate, however, that for the angularity of such seams with the length of the boiler as usually found, a close approximation to the true value can be obtained in a simple manner. In order to avoid confusion, it should be understood that the efficiency of a joint should be considered the same whatever its position, for it should express its strength as compared with that of the solid plate, and this ratio does not change, no matter what its position on the boiler shell.



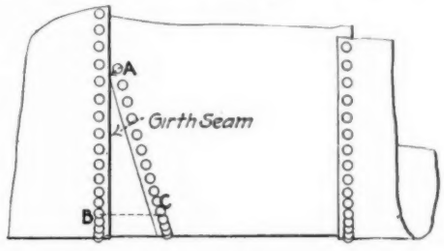


FIG. 1, RULE 1.

If a boiler has a patch with a diagonal seam, as shown in Fig. 1, the question to be determined is not the efficiency of the seam *BC*, but the relative strength of this seam to resist internal pressure as compared with the solid sheet along a line parallel with its length. In all cases where angle x is not over 45 deg., this relative strength of the diagonal seam and that of the solid plate along a longitudinal line can be determined, with a maximum error of about 3 per cent., which occurs when the angle x is 45 deg.; at 30 deg., the error is only $\frac{1}{10}$ of 1 per cent. This method (Rule 1) consists of finding its efficiency in the usual manner and multiplying it by the result found by dividing length *BC* by length *BA*. Thus, if the efficiency of seam *BC* was 52 per cent., and the angle of the seam to the length of the boiler was such that the distance from *B* to *C* was 25 in. and *B* to *A* was 20 in.; then

$$0.52 \times \tfrac{2}{2}\tfrac{0}{5} \text{ or } 0.65$$

would represent the strength along *BC* as compared with the strength of the solid plate along any horizontal line, as *BA*.

The reason an inaccuracy results in calculating joints of greater angularity is that, as they approach the vertical position, the effect of the longitudinal stress (which affects the girth seams of a boiler) comes into play. In the above calculation, no account is taken of the stress lengthwise.

In order to avoid mathematical formula, a graphical method for determining the strength of diagonal seams where angle x is over 45 deg. will be given (Rule 2), which can, of course, be used for joints of any angle, if the method already given is not sufficiently accurate. If the strength of a seam *AC*, Fig. 2, is desired, first figure the efficiency of the seam along *AC* in the usual manner; then draw line *BC* parallel with the axis of the boiler and measure the lengths of lines *AB*, *AC* and *BC*. It does not matter just what length is chosen for *AB*, but it should be long enough to make accurate measurements possible, say, 18 to 24 in. When this has been done, reproduce triangle *ABC* (on a drawing board or other place where lines can be accurately made), as Fig. 3.

Through *A*, line *AH* should be drawn perpendicular

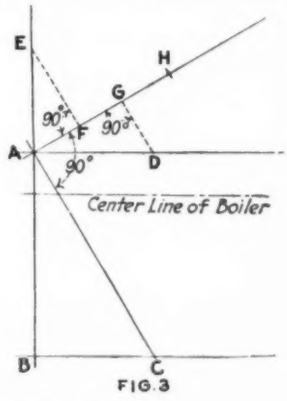


FIG. 2 AND 3. RULE 2.

to line *AC*, and line *AD* should be drawn parallel to the axis of the boiler and *AE* as a continuation of the line representing the girth seam of the boiler. Now, dividing *AB* by *2AC*, a certain result is obtained. This should be laid off as a distance from *A* to *E*, using any convenient scale, similarly dividing *BC* by *AC*, another result is obtained, which should be laid off as *AD*, to the same scale as used in laying off *AE*.

From *D* and *E*, perpendiculars should be dropped on line *AH* as shown, and the distance from *A* to *E* should be laid off beyond *G* as *GH*. Now, the distance from *A* to *H* represents a value (when estimated by the same scale as used in laying off *AE* and *AD*). By dividing the efficiency of the seam along *AC* by this value, the result will be the relation between the strength of the solid plate along the length of the boiler and the strength of the seam along *AC* when the boiler is subjected to internal pressure.

The above explanation sounds complicated, but a numerical example will show that it is not really so.

*See also "Patching Boilers," Aug. 25, pages 275 and 280, and this issue, page 355.

Assume $AC = 20$ in., $BC = 10$ in. and $AB = 17.3$ in.; then

$$\frac{AB}{2AC} = \frac{17.3}{40} = 0.433$$

and this would represent the distance AE, which is laid off in inches on a scale of 4 in. equals 1 in the figure.

$$\frac{BC}{AC} = \frac{10}{20} = 0.5$$

which is laid off as AD to the same scale of 4 in. equals 1. Now it is a simple matter to drop the perpendiculars EF and DG on line AH, and by adding the distance AF to AG, we have 0.656 as the length of AH measured by the same scale of 4 to 1. If the joint along AC had an efficiency of 50 per cent., its strength with respect to that of the solid plate along AD would be

$$\frac{0.50}{0.656} = 0.762 \textit{ per cent.}$$

This means that the strength of the boiler along the seam AC is the same as if this seam was longitudinal and had an efficiency of 76.2 per cent. These seams have been figured as if they were located on a plain cylinder, and the internal pressure was free to produce a stress lengthwise as well as girthwise of the boiler. In the case of the horizontal return-tubular boiler this is not true, since the tubes and through braces support the heads and relieve the shell of a very considerable portion of the load, due to the pressure on the ends of the boiler.

It will be seen that the method here described for obtaining the strength of diagonal boiler joints is merely resolving the longitudinal and girthwise stresses to obtain their components at right angles to the direction of the joint; that the reason for dividing AB by $2AC$ is because the longitudinal stress is one-half that girthwise of the shell.

J. E. Terman.

Hartford, Conn.

Cost of Operating a Vacuum Ash-Handling System

The articles* relative to suction ash-handling equipment were read with interest, as at the plant under my supervision an ash-handling plant of the suction type was installed about four years ago.

Seven cents a ton, the figure quoted in the issue of July 7, seems so low that it must cover only part of the removal costs per ton of ash, as it is less than half what our removal power costs us—14.6c. per ton, and the power costs 1c. per kw-hr.

The original specification for this equipment called for 20 tons per hour, but on test it only handled about 10 net tons. Under everyday use, 2½ to 3 tons is about the limit.

The piping has been renewed twice in four years, and the depreciation on this end of the system is 50 per cent. The wearing backs in the elbows last from three to four months; no repairs have been made to the tank, but it has been painted twice.

In the boiler plant are four 450-hp. and six 375-hp. water-tube boilers. The amount of ash handled per year is 2500 tons

The average yearly charges are 36,500 kw., at 1c. per kw., $365, which divided by 2500 tons makes a power cost of 14.6c. per ton. Labor for the year is $1186, which divided by 2500 tons makes the labor cost 47.44c. per ton. The average cost per year for repairs for the four years was $1106, which divided by 2500 tons makes the repair cost 44.24c. per ton. The interest charge on the original investment, $7800, at 6 per cent., is $468, which divided by 2500 tons makes the interest 18.72c. per ton.

Taking the per-ton costs, we have, power, $0.146; labor, $0.4744; repairs, $0.4424; interest, $0.1872, making $1.25 the total cost per ton of ashes removed. A skip and hoist could remove ashes for a much lower figure.

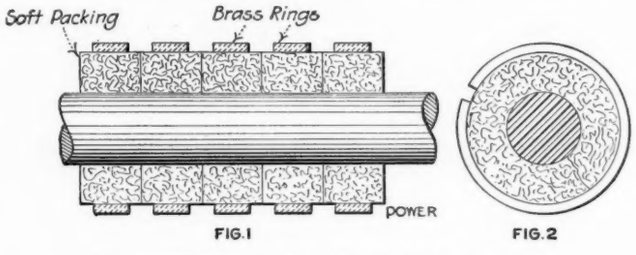
Alexander Arnois.

Philadelphia, Penn.

*April 7, July 7, 1914.

Packing a Worn Rod

Edward T. Binns described on page 106, July 21, a packing for a worn rod. The way I pack worn pump cylinders can also be used in packing a worn rod. Use hard brass spring rings about $\frac{1}{16}$ in. thick and about two-thirds the width of the packing rings. Cut the packing the proper length, place the brass ring over the packing, and insert both into the stuffing-box. When in place, the



Packing and Brass Rings in Position

packing should be as shown in Fig. 1; Fig. 2 is an end view.

It will be found that the packing will conform to the different diameters of the worn rod without excessive friction, as the brass rings will yield as the rod passes through the stuffing-box. I have described this same design, reversed in position, to be used on plungers of inside-packed pumps.

James E. Noble.

Toronto, Ont., Can.

Surging in Discharge Pipes

In reply to J. F. Hurst on the above subject on page 30, July 7, I would suggest that he place an air vent at the highest point of the delivery pipe, and ascertain the number of revolutions required to deliver the water to its destination. If the pumps are engine driven, set a speed enough higher to allow the required speed when the pump is doing its maximum work at full load.

The pump should also be fitted with a gate valve on the outlet side and this valve regulated to suit the amount of water to be passed, it being borne in mind that the power used by a centrifugal pump varies with the weight of water passing through it.

E. R. Pearce.

Rochdale, England.

An Interesting Cylinder Failure

The cylinder explosion described by M. C. Maynard, on page 218, Aug. 11, is interesting, but not entirely surprising.

It is unreasonable to expect a crippled engine to do as much work as when in good condition. The explosion would not have occurred had the engine been slowed down to at least half speed after the intermediate valve was broken; but as the engine was run at full speed on two cylinders, with the torque very uneven, there is little wonder that the part of the piston resting on the shoulder of the rod gave way and fell on the cylinder head, causing it to break away and destroy the entire cylinder. Engines have been run with one cylinder cut out, but they were run at a moderate speed.

Marine engines are subject to great shocks due to the pitching of the ship and counter-currents; and for this reason a great many things which can be done safely with a stationary cannot be done with a marine engine.

SAMUEL L. ROBINSON.

U. S. S. "Connecticut."

As the intermediate cylinder was out of service, more work was thrown on the high- and low-pressure cylinders, which caused a larger demand for steam and lifted the water in the boilers. That fact is clearly proved by the groaning noise in the cylinder, for water will cause that, as I have experienced many times; and Mr. Maynard may rest assured that the accident occurred when the water in the boilers was high, and the result was a large dose of water entering the cylinder, probably accelerated by the ship's pitching.

FELIX HELSMOORTEL.

Saugerties, N. Y.

The accident described on p. 218, Aug. 11, was probably caused by the explosion of the piston from an accumulation of water. It may have been a poor casting, with slag in the iron, and when condensation would take place in the cylinder the water leaked into the hollow core of the piston and was held there by the foundry sand left inside acting as a check valve. When the cylinder warmed up, the water became steam which exploded the piston near the top of the cylinder, at the point of cut-off. This may hasve been the cause of the cylinder head dropping out and the cylinder bursting. The noise probably was the water boiling in the piston.

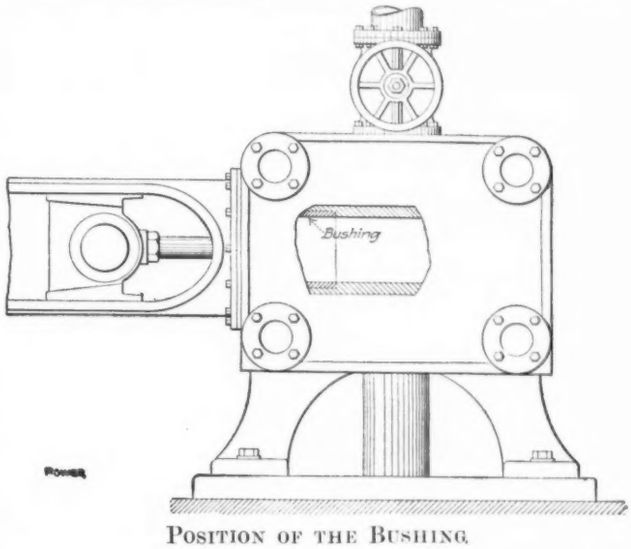
WILLIAM REDFORD.

Jersey City, N. J.

H. B. Boydon's article on page 60, July 14, brings to mind an experience of nine years ago.

The engine was an 18x36x36-in., cross-compound condensing corliss, running at 120 r.p.m. One afternoon the crank end key on the high-pressure side became loose and was thrown out, allowing the piston to strike the cylinder head. The engine was shut down and examined, but no damage could be discovered, so it was put in service again next morning. After having been in operation about two hours, it was noticed that steam was escaping from beneath the high-pressure cylinder. It was again shut down and the lagging removed, when a crack was discovered extending in from the head at the crank end of the cylinder, down under and around to the head again. Two 1-in. bolts were run from head to head and drawn up tight, but they did but little good. We could not obtain another cylinder for six weeks, so it was decided to repair the broken one.

The cylinder was disconnected from the frame and with a portable boring bar it was bored out half-inch larger and six inches beyond the crack. The crack was then made steam tight with iron cement. A cast-iron bushing cast and turned up to the proper size in a local machine shop was forced into the place prepared for it. A light cut was then taken through the cylinder, after



POSITION OF THE BUSHING

which it was replaced and put in service, and I believe it is still in use. The entire repair cost less than $50, while a new cylinder would have cost about $350.

I have since had an engine that developed a leak through the lagging of the cylinder, and upon examination a similar crack was found. When the cylinder was opened I discovered a bushing similar to the one described, but I presume the break was not made steam tight before the bushing was put in and the steam worked around it.

LOUIS B. CARL.

Marshfield, Wis.

Patching Boilers

After reading C. J. Hawkins' inquiry on page 25, July 7, I looked up the rule in Mason's "Arithmetic of the Steam Boiler," which is as follows, but I have some doubts in regard to it.

Taking the efficiency of the joint as though it were a longitudinal joint, then "multiply the length of the seam in inches by the efficiency of the joint and divide by the length in inches measured along a line parallel to the axis of the cylinder."

This is equal to the secant of the angle times the efficiency of the joint.

Now the secant of the angle varies from 1 to ∞ as the angle increases from zero to 90 deg. Evidently one may, by varying the angle, obtain almost any efficiency between the given efficiency and an infinite one. I would be very glad to have this matter explained and also a reliable method given for finding the efficiency of a diagonal joint.

DALE S. MILES.

Independence, Kan.

Lead Boiler Gaskets*

Molds for lead gaskets described in recent issues are good, but unnecessary, as lead gaskets should not be solid. More satisfactory results can be had by using gaskets made of soft lead tubing having an outside diameter of about nine-sixteenths. The pipe should be formed to the desired shape and its ends either burned or soldered together. A number of small holes through the side farthest from the pressure will let the air out as the joint is made up. Lead piping is usually softer than cast lead and readily allows for any rough surfaces and such gaskets may be used a number of times, and are quite suitable for pressures up to 250 lb. for both hand and manhole joints.

E. T. Binns on page 30, July 7, gives good advice for the treatment of soft gaskets, but why use soft gaskets when lead is much more satisfactory?

E. R. Pearce.

Rochdale, England.

[The other contributors have featured remelting and using old lead.—Editor.]

Figuring Radiation

There are several methods of figuring radiation, beginning at practically guesswork, in allowing a certain number of cubic feet per square feet of radiation and ending with the B.t.u. method in which all the various losses are supposed to be accurately computed and the proper amount of radiation found to offset the losses. But is it possible to accurately figure radiation? I hardly think so and to satisfy myself on this point I made an investigation of the constants used by the different writers. The following table is interesting in showing the wide variation among men who are recognized as authorities in the heating line. Who will say which are the correct constants?

B.T.U. RADIATED PER SQ.FT. PER DEGREE DIFFERENCE IN TEMPERATURE PER HOUR

	Thompson	Gifford	Allen	Carpenter	A. Wolff	Hoffman
Brick wall 8"		0.48	0.25	0.37	0.46	0.40
12"	0.265	0.33	0.21	0.32	0.32	0.31
16"	0.210	0.26	0.19	0.28	...	0.26
20"	0.187	0.21	0.16	0.26	...	0.23
24"	0.167	0.19	0.14	0.24	0.20	0.21
28"	0.152	....	0.13	0.22	0.174	0.19
32"	0.13	....	0.12	0.21	0.15	0.17
36"	0.12	0.12	...	0.20	0.13	...
Single window	1.00	1.07	1.06	0.91 to 0.98	1.09	1.0
Double window	0.50	0.73	0.46	.....	0.52	0.60
Single skylight	1.50	1.04	1.16	.....	1.12	1.10
Double skylight	0.50	0.61	0.48	.....	0.62	0.70
Door	1.00	0.40	0.41	.....	0.414	0.4
Stud partition—lath and plaster one side	0.60	0.40	0.60	.....	.....	0.60
Stud partition—lath and plaster both sides	0.34	0.31	0.34	.....	.....	0.34
Lath and plaster ceiling	0.32	0.40	0.62	.....	.....	0.62
Floor	0.10	0.34	0.45	.....	.....	0.45
Floor—lath and plaster	0.08	0.27	0.26	.....	.....	0.26
Double floor	0.08	.29	0.31			
Double floor—lath and plaster	0.06	0.19	0.18			

The B.t.u. method of figuring radiation is almost universally used where any sort of consistent results are desired, but it is hardly more than an intelligent guess with the present uncertainty as to the real value of radiation constants. Most engineers are inclined to use the higher constants and base their computations on minimum temperatures that are only reached once or twice a season, thus being on the safe side. This often results in more radiation than is actually required and a corresponding increase in cost.

The U. S. Bureau of Standards has made elaborate tests along a great many engineering lines. Penn. State College has recently put into commission a thermal testing plant for standard forms of insulation. Is not the subject of enough importance for one of the above institutions or some other college equipped for testing work to make accurate tests of heat transmission on modern forms of building construction? If this were done the determination of the proper amount of radiation for a building would pass from the land of uncertainty to exactness.

W. L. Durand.

*"Power," Apr. 28, July 7 and 14.

Air-Compressor Troubles

On starting up a new two-stage air compressor, trouble developed in the high-pressure cylinder. An obstruction in the passages would let only a small amount of water through. After removing the cylinder head, everything seemed clear until a wire was entered in the passage leading to the rear head, which was found to be filled with molder's sand. The opening to the crank end of the cylinder was nearly closed with metal, the core evidently having shifted a little, and cutting this out was a tedious job. After replacing the head, a free flow of water reduced the temperature of the heads.

Oil carbonizing in this cylinder was another source of trouble. Several grades were tried with poor results. Polarine seemed to stop the groaning of the inlet valves, which happened every time the machine was shut down, but this oil also carbonizes a little. I feed it at 1½ drops a minute, but if further diminished the lubricators refuse to work regularly.

This machine is belt driven from a 200-hp. motor and is governed by an unloader on the intake pipe. Its capacity is somewhat greater than the demand for air at present, so it runs light about one-third of the time. I believe this is the cause of my trouble. The oil does not leave the cylinder fast enough when the machine is running light, and is carbonized by the heat, and the demand for air is very irregular. If a smaller amount is used, the valves stick and quiver when running under a load. Perhaps someone can suggest a remedy.

License Laws and Wages

I do not believe license laws alone will raise the engineer's pay. Ohio has had a license law for several years and it seems to attract men in excess of the demand, thereby keeping the pay low in proportion to the amount of work and study required.

The law provides that an applicant shall make oath that he has been employed at least one year as an engineer, oiler or fireman. I know at least one case where the applicant, after he had failed at the examination, said he had never worked as required by the law, but could get a job any time.

F. D. Crain.

Willshire, Ohio.

Inquiries of General Interest

Melting Point of Babbitt Metal—What is the temperature of the melting point of ordinary babbitt metal?

R. N. V.

Commercial babbitt metal is made in a variety of proportions of tin, copper, antimony, zinc and often lead, with an average melting point of about 1000 deg. F.

Removing Oil from Boilers—How can boilers be cleaned of oil deposited in them by using feed water returned from a surface condenser?

A. S.

By using a solution of soda ash and water boiled up in the proportion of about 1 lb. per 10 hp., after which the boiler should be blown off and washed out.

Condensing Surface per Kilowatt—What proportion of condensing surface is allowed for operation of large turbo-condensing units?

E. C. S.

In operation of large turbo-condensing units it has been determined by experience that satisfactory results are obtained by employment of 1.6 sq.ft. of condensing tube surface per kilowatt.

Direct-Motion Hoisting Engine—What is the distinctive characteristic of a direct-motion hoisting engine?

F. B. N.

A direct or first-motion hoisting engine is one which has the winding drum mounted on the main or crankshaft of the engine, as distinguished from a second motion hoisting engine which has its winding drum driven by a gear wheel on the engine crankshaft.

Thickness for Babbitting—How can I proceed to get the correct measurements for rebabbitting the bottom shell of a four-part bearing without stripping the engine?

H. R.

Raise the shaft up until it is level, and when in it is also held in proper alignment, the distance the journal is vertically away from the old babbitt added to the vertical thickness of the old babbitt, will give the vertical thickness for the new babbitt at any point so measured.

Inequality of Draft of Connected Boilers—In a battery of eight boilers, if a stack connection of uniform size extends along the rear of all the boilers from No. 1 to No. 8 and is thence connected into a stack of the same diameter and there is an uptake from each boiler to the horizontal stack connection, will boiler No. 1 or No. 8 have the better draft?

M. G.

If the uptake of each boiler has a right-angled connection with the common stack connection and no baffles are employed, then the boiler furthest from the stack will have the better draft.

Connecting Drips of Vacuum-Heating System—In a vacuum-exhaust steam-heating system, how can the drips of mains be connected to the returns so as not to sustain loss of steam or impair vacuum in the returns?

J. H. N.

A main drip should be sealed by running it so as to form a deep trap before discharging to the returns. The highest point of the trap so formed should be at least 20 to 30 in. lower than the connection to the steam main, and the deeper the trap the higher the vacuum may be carried before siphoning will take place.

Horsepower of Alternating-Current Motor—How is the horsepower found on a three-phase a.c. motor when voltage and amperage are given?

E. F. R.

The power of a three-phase motor is given by the formula

$$KW = \frac{\text{Current} \times \text{voltage} \times 1.73 \times \text{power factor}}{1000}$$

This applies to the current in any phase, and the voltage is that measured across any two of the live wires. As one horsepower is equivalent to 0.746 kilowatt, the horsepower of the motor would be the kilowatts found by the formula divided by 0.746.

Connections for Exhaust Steam Heating—Should heating coils and radiators which are supplied with exhaust steam have single or double connections?

W. N. J.

When the supply of exhaust steam is continuous and practically uniform in pressure and operated as a closed gravity-return system, either single or double pipe connections may be employed as in ordinary low-pressure steam-heating, but when the returns are discharged as a vacuum system or for blowing out the heating system of air and water to quicken the circulation, the coils and radiators should be provided with separate steam and return connections.

Size of Motor for Centrifugal Pump—A centrifugal pump has a rated capacity of 250 gal. per min. pumping against a total head of 120 ft. with an efficiency of 53 per cent. What size of motor should be selected to drive the pump?

S. B. R.

Pumping 260 gal. per min. against a total head of 120 ft. with an efficiency of 52 per cent. would require:

$$\frac{260 \times 8\frac{1}{3} \times 120}{0.52 \times 33{,}000} = 15.12 \text{ hp.},$$

and allowing 10 per cent. loss in transmission the power of the motor should be

$$\frac{15.12}{100 - 10} = 16.8 \text{ hp.}$$

Size of Pump for Vacuum-Heating System—What is the formula for size of pump for a vacuum steam-heating system?

F. P.

A formula for the approximate size of air cylinder for a vacuum pump of a vacuum steam-heating system is

$$d^2 \times L = \frac{S}{35}$$

in which

d = Diameter of air cylinder in inches;
L = Length of stroke in inches; and
S = Number of square feet of radiating surface to be drained.

Temperature Difference of Steam and Discharged Condensing Water—What is the temperature difference between the steam and condensing water as discharged from a condenser?

W. J.

In good practice, there is a difference of 10 deg. to 15 deg. F. between the temperature of the outgoing cooling water and temperature of the incoming steam, depending on the type of condenser and volumetric ratio of water to steam. A good surface condensing plant with dry-air pump should operate at 28 in. vacuum with a temperature difference of 15 deg. F., but there are many plants which are operated with a difference of 25 to 40 deg. Although it may be possible for a good barometric or centrifugal jet condenser to operate with less temperature difference than 10 to 15 deg., commercial practice rarely concedes better results.

Pump Capacity—How much water per hour will a duplex steam pump handle having a 6-in. steam cylinder, 4-in. water cylinder and 6-in. stroke, when making 75 r.p.m.?

F. C. L.

The cross-sectional area of the water cylinder, neglecting the area of the rod, is

$$4 \times 4 \times 0.7854 = 12.566 \text{ sq.in.}$$

The displacement for one 6-in. stroke would be

$$12.566 \times 6 = 75.396 \text{ cu.in.}$$

and for 150 (i.e., 2 × 75 r.p.m.) strokes and two cylinders (the pump being duplex) would be

$$75.396 \times 150 \times 2 = 22{,}618.8 \text{ cu.in. per min.}$$

or

$$\frac{22{,}618.8}{231} = 97.917 \text{ gal. per min.}$$

or

$$97.917 \times 60 = 5875.02 \text{ gal. per hr.}$$

These figures do not take slippage into account.

Engineers' Study Course

Elementary Mechanics--XXV

LAST LESSON'S ANSWERS

111. Since there are four threads per inch, the pitch is ¼ in. Let Fig. 75 represent the development of the thread. The base of the plane is the circumference of the screw; the altitude is the pitch; and the hypotenuse AC is the length of the thread. The motion of the jack is equivalent to motion on the inclined plane AC.

By construction

$$tan\ a = \frac{BC}{AB} = \frac{\frac{1}{4}}{6.28} = \frac{1}{25.12} = 0.04 \quad \text{(approximately)}$$

From a table of tangents the value of the angle a is found to be 2 deg. 20 min. From equation (66) the efficiency of the inclined plane is $E = \frac{1 - f\ tan\ a}{1 + f\ cot\ a}$

From the conditions of the problem the value of f is 0.14; the $tan\ a = 0.04$ and the $cot\ a = 25$. Substituting these values in equation 66, the efficiency of the jack is found thus:

$$E = \frac{1 - 0.14 \times 0.04}{1 + 0.14 \times 25} = \frac{0.9944}{1 + 3.5} = 0.22 \textit{ or } 22 \textit{ per cent.}$$

112. In one revolution of the lever the point A will move a distance equal to $2 \times 3.1416 \times 2$ or 12.56 ft. The force exerted by the man is 40 lb. and the work done per revolution of the jack is 40×12.56, or 502 ft.-lb., which quantity represents the *input*.

Let W equal the weight raised. In one revolution of the jack this weight will move a vertical distance of ¼ in. or the pitch of the screw. Hence the *output* $= W \times ¼ = W/4$ in.-lb., or $W/48$ ft.-lb. By equation 53 $efficiency = \frac{output}{input}$. In problem 111 the efficiency of the jack was found to be 22 per cent. Substituting the values of the efficiency, input, and the output in the above equation there results,

$$0.22 = \frac{W/48}{502} \text{ or } W = 0.22 \times 502 \times 48 = 5300\ lb.$$

113. The effective force moving the car down the plane is the force of gravity minus the force of friction. From the discussion of the inclined plane the force of gravity, G is $W \times sin\ a$. In this problem $sin\ a = 1/18$, hence

$$G = W\ sin\ a = 2000 \times 1/18 = 111\ lb.$$

As the force of friction F is assumed to be 20 lb., the effective moving force is

$$(G - F) = (111 - 20) = 91\ lb.$$

The acceleration a may be found from equation 49, where $F = \frac{W}{g} \times a$, or

$$a = \frac{F \times g}{W} = \frac{91 \times 32.16}{2000} = 1.46\ ft.\ per\ sec.$$

114. Use the equation (32) $V^2 = 2\ aS$. Here $a =$ 1.46 ft. per sec., and $S = 500$ ft.; therefore,

$$V^2 = 2 \times 1.46 \times 500 = 1460, \text{ or}$$

$$V = \sqrt{1460} = 38.2\ ft.\ per\ sec.$$

115. The car, including the load, weighs 2000 lb., and its velocity at the foot of the plane is 38.2 ft. per sec. The kinetic energy in the car, due to its velocity, is $\frac{WV^2}{2g}$, or $\frac{2000 \times 38.2 \times 38.2}{\times 32.16} = 45{,}374\ ft.\text{-}lb.$

This energy must be absorbed before the car will come to rest. When the car is running on the level the only resistance to be overcome is the force of friction which, in this case, is 20 lb. The work done in overcoming this resistance through a given distance of S ft. is $F \times S$ ft.-lb., which must equal the energy in the car, or $F \times S = \frac{W \times V^2}{2g}$, where $F = 20$ lb., and $\frac{WV^2}{2g} = 45{,}374$ ft.-lb. Hence, $S = \frac{WV^2}{2gF} = \frac{45{,}374}{20} = 2268$ ft.

PROJECTILES

In the previous lessons the motion of a body was limited to straight lines. There are cases where the path of the body may be a curve. If an object be projected vertically upward it will rise in a straight line to a certain height and then descend in the same straight line. If, however, the object be projected at an angle to the vertical the path described will be a curve, the form of which will be determined. In the following discussion the resistance of the air will be neglected, as an attempt to correct for it would require a knowledge of mathematics beyond the scope of this work. The acceleration due to gravity will be considered as uniform.

When an object is projected into the air, the angle that the direction in which it is projected makes with the horizontal is called the *angle of projection*. The path the object describes is called its *trajectory*. The distance from the point of projection to the point where the object again passes the plane of projection is called the

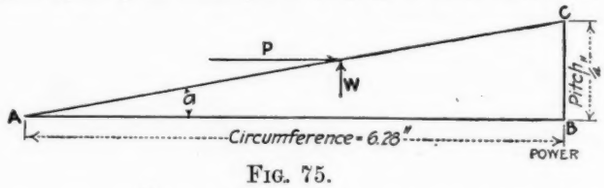


FIG. 75.

range. The time that elapses before the object meets the plane of projection is called the *time of flight*.

As stated in Newton's second law of motion, a body would continue to move in a straight line forever if it were not for other external forces which are brought to bear on the body. The instant a bullet leaves a rifle gravity acts and tends to change the path of the bullet.

Projectiles may be divided into several classes, depending upon the angle of projection.

Class I. Bodies projected vertically upward. (This class has been discussed in lessons XVIII and XIX.)

Class II. Bodies projected horizontally from a point at some elevation above a given reference plane.

Class III. Bodies projected at an angle to the horizontal.

In Fig. 76, assume an object to be projected horizontally from the point C with a velocity of V ft. per sec. Let H = the elevation, in feet, of the point C above the horizontal plane AB. It is desired to find at what point B the object will reach the ground and also the time of flight from the point C to the point B.

At the end of the first second the projectile would be at the point E, a distance of V ft. from the point C, if it were not for gravity, which in the same second causes the projectile to fall a distance of $\frac{1}{2}\ g$ ft. The net result is that at the end of the first second the body is not at the point E, but at a point M, 16 ft. below E. Likewise

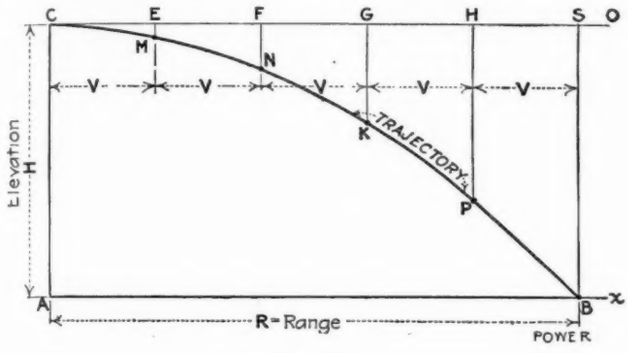


FIG. 76.

at the end of the second second the body would be at the point F, due to its initial velocity, but during these two seconds gravity causes it to fall a distance of

$$\frac{1}{2}\ gT^2 = \frac{1}{2} \times 32.16 \times 2^2 = 64 \text{ ft.}$$

so that the projectile is at the point N, which is located 64 ft. below F. At the end of the third second the projectile is at the point O, which is $4\frac{1}{2}\ g$, or 144 ft. below G. Hence to plot the true path of the projectile, the following method may be used:

Lay off the vertical distance H (Fig. 74) to a definite scale; that is, one inch of height represents a fixed number of feet. Draw the horizontal reference line AX, and through the point C draw the line CO parallel to the line AX. On the line CO locate the points E, F, G, etc., so that the distance between any two consecutive points is equal to the initial velocity of the projectile in feet per second. Through the points E, F, G, etc., draw vertical lines, and on these lines lay off distances equal to the space through which a body would fall due to gravity in the given number of seconds. Thus at the end of the first second the body would have fallen a distance of 16 ft., and so the distance EM is made 16 ft. to scale. The distance FN is 64 ft., GK is 144, etc. A smooth curve drawn through the points C, M, N, K, B, will give the trajectory of the projectile.

The time of flight will be the same as if the projectile had been let fall from the point C and has nothing to do with the initial velocity of the projectile, but is entirely dependent upon the vertical distance AC. The simultaneous action of the velocity V and the action of gravity produce the same effect as though these forces acted independently of one another, that is the projectile may be considered as first moving from the point C to the point S with a velocity of V ft. per sec., and then falling, due to gravity, from the point S to the point B.

The time that it takes for the projectile to fall the vertical distance AC or H ft. may be found from equation (42) where $H = \frac{1}{2}\ gT^2_1$; and when the time is known the horizontal distance AB or the range is found from the equation $S = V \times T_1$. Therefore, let T_1 = the whole time of flight; H = the vertical distance from the plane AB to the point of projection; V = the velocity of projection in feet per sec.; and R = the horizontal range or the distance AB.

Then
$$T_1 = \sqrt{\frac{2H}{g}} \qquad (67)$$

and
$$R = V \times T_1 \qquad (68)$$

or
$$R = V\sqrt{\frac{2H}{g}} \qquad (69)$$

The above formulas apply only to problems coming under Class II.

STUDY QUESTIONS

116. A horizontal belt conveyor is located 100 ft. above the ground. Coal leaves the conveyor with a horizontal velocity of 20 ft. per sec. How long after the coal leaves the conveyor will it strike the ground?

117. Find the horizontal distance from the conveyor to the point where the coal strikes the ground.

118. Find the magnitude and direction of the velocity of the coal when it strikes the ground.

119. In Fig. 14, lesson IV, the governor ball B is 15 in. from the center of the spindle when revolving at 100 r.p.m., and is 15 ft. above the floor line. If the ball were to suddenly break loose from the spindle, how far would it travel before striking the ground?

120. What would be the time of flight?

Engine Throttle Valves

In the account of the flywheel explosion at the Union Brewing Co.'s plant, page 115, July 21, the picture shows that the throttle valve had a long stem which brings the wheel out over the valve-gear and in line with the flywheel. Engine builders are not giving the position of the throttle valve the attention that it should have from the viewpoint of the safety of the engineer.

All engines of even moderate size should be equipped with an engine stop which will close the throttle in an emergency, but they are not always provided and it is often difficult to get the company to incur the expense. When the valve with a long stem is used there should be a bearing for the stem near the handwheel to prevent the side strain causing the stem to become sprung.

Another trouble sometimes found is that the packing gland is drawn up too tight. This should not be done. The packing should be renewed often enough to prevent it from becoming hard. Some engineers on opening the throttle or other valve, turn it wide open, and wedge the stem tight. When left in this position the valve is hard to start when it is to be closed. A valve should be opened wide, then turned back part of a turn to free it.

A handwheel of small diameter with a polished rim should not be used. In the case referred to if the throttle had been arranged as suggested, it is likely the engineer could have closed it quickly, preventing the accident.

Ice Making in Ireland—In the city of Cork there is, it is reported, only one ice plant, which supplies all the ice for domestic and public use for the entire southern part of the island. The output is only six tons per day. There are a few individual firms operating refrigerating machinery for their own use.

Fireman Fatally Scalded

On July 30, at 7:30 in the morning, Peter McArdle, a fireman, was scalded to death in the plant of the Mallers Building, 237 South Market St., Chicago. The plant is equipped with two Scotch boilers which operate on pressures of from 60 to 100 lb., the safety valves being set for 105 lb. The blow-off pipes are carried out at the sides of the boilers and by means of a tee connection discharge through a common pipe running to a cast-iron blowoff tank at the rear of the boilers. The room here is restricted and the ground level is four steps below the basement floor. To get at the blowoff valves it is necessary to enter a narrow space between the two boilers.

The tank was 23 years old and showed signs of serious corrosion. On this account it had been the custom to blow down at a pressure not exceeding 20 lb., but on the fatal morning full pressure was on the one boiler which was in operation when the fireman started to blow it down. Just as he opened the valve, the bottom blew off of the tank, forcing the rest of it upward. Naturally, the piping was carried along with it and the latter in turn pulled the tee away from the blowoff pipes. The hot water and steam rushing out overpowered the fireman and before help could reach him he was fatally scalded.

Effect of Different Methods of Lubrication on the Moving Parts of Reciprocating Engines*

Experiments have been made to determine the impact on the bearings of reciprocating engines with different methods of lubrication with the idea of reducing noise and shock. The engine used was a single-cylinder, double-acting center-crank type with Corliss valve gear, 7-in. cylinder diameter and 17½-in. stroke, the speed varying from 50 to 125 r.p.m. The force of impact was measured by an inertia apparatus fixed to the connecting rod and by an electric circuit. Indicator diagrams were taken with a drum motion proportional to the time. With this measuring apparatus the force of impact, or the greatest retardation during the change of pressure, was obtained, also the point of the crank circle where the change of pressure took place. Different tests were made for several cutoffs, several lengths of compression, under varying speed, for different kinds of lubrication and for different clearances in the crank and crosshead bearings. Lubrication was applied in three different ways:

1. With sight feed oilers—drop lubrication.

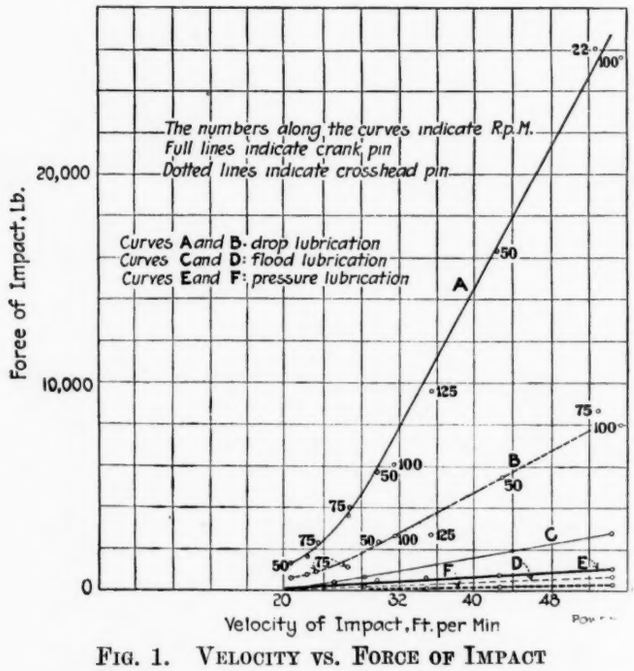


FIG. 1. VELOCITY VS. FORCE OF IMPACT

2. Forced lubrication under a head of 12 in.—flood lubrication.

3. Forced lubrication with a head of 15 ft.—pressure lubrication.

Results of the tests are shown in the two diagrams. Fig. 1 gives the force of impact plotted against the velocity of impact. The full lines relate to the crankpin, the broken lines to the crosshead pin. The speed of the engine is given by the numbers along the curves. The most striking feature of this diagram is the great advantage of continuous lubrication over intermittent lubrication. The improvement of curves C and E over curve A (for the crankpin), or of curves D and F over curve B (for the crosshead pin), is so striking that it is unnecessary to make any further comment.

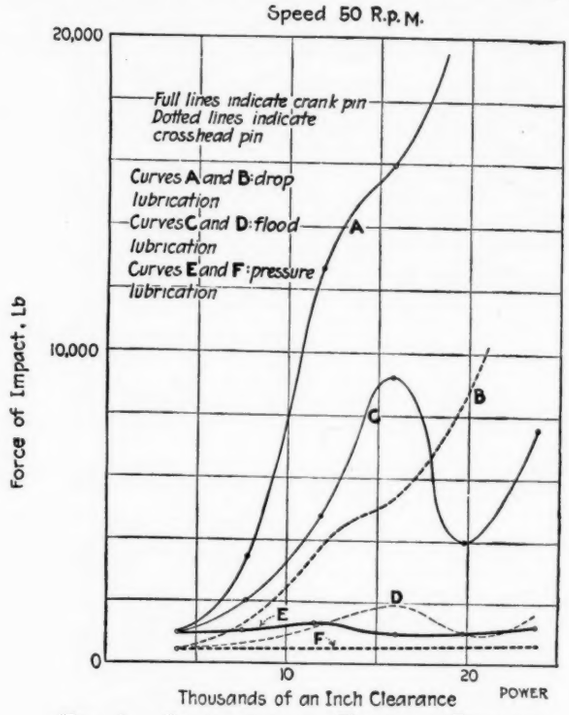


FIG. 2. CLEARANCE VS. FORCE OF IMPACT

Fig. 2 shows the influence of lubrication on the force of impact for different clearances between the pin and bearing. The result is the same—great advantage of continuous (flood or pressure) lubrication over intermittent (sight feed or drop) lubrication.

It may be interesting to add the conclusions the author draws from his experiments. He says:

1. The point of the crank circle in which the change of pressure takes place has no influence on its magnitude, as shocks occurring at dead center may be just as light or heavy as shocks before or after the dead center.
2. The speed of the engine influences the amount of change in pressure only in combination with the shape of the indicator diagram. (Compression line and inertia line.)
3. Lubrication has the greatest influence. Insufficient lubrication means heavy shocks under all circumstances. High oil pressure shows some improvement over low oil pressure, but not as much as flood lubrication shows it over drop (sight feed) lubrication.

The Illuminating Engineering Society will hold its annual convention in Cleveland, Ohio, Sept. 21 to 25, inclusive. A most interesting list of papers will be read and discussed.

A New High-Power Water Pump, with a capacity of 30,000,000 gal. a day, built by the Allis-Chalmers Co., was recently installed under the supervision of Wayne W. Mackey, erecting engineer of the company, at the Broadway pumping station of the T ledo Water Works, Toledo, Ohio. It has the distinction of being one of the greatest pumping engines of its class ever constructed, and cost $83,000. The pump is of vertical triple-expansion design, and the cost of operation is estimated as ne-sixth of the cost of maintenance of the original 5,000,000-gal pumps formerly used. It will increase the water providing capacity of the Broadway station to 72,000,000 gal. daily. Toledo's normal daily supply is less than half of this amount. All of the cylinders, heaters and steam lines connected with this pump are insulated with coverings furnished by the H. W. Johns-Manville Co.

*Translated and abstracted by W. Turnwald from a report by Dr. Ing. Hans Polster in "Zeitschrift des Vereines Deutscher Ingenieure."

Australian Meeting British Association for the Advancement of Science

The Association is this year repeating its custom, initiated in 1884, of holding occasional meetings in the British Colonies. The first meeting of this kind was held in Montreal in 1884; Toronto was visited in 1897, Winnipeg in 1909; South Africa in 1905, and Australia was selected for 1914. Two large parties of delegates left the home country for Australia at the end of June and early in July, and these were reinforced when they arrived, by the local Australian members, and by others who joined as associates for the Australian meeting only. The meetings were held during July and Aug. in Perth, Adelaide, Melbourne, Sydney and Brisbane, the five state capitals.

PRESIDENTIAL ADDRESS

Professor Coker, in his address to the Engineering Section, dealt with "Stress Distribution in Materials." Different methods for investigating stress distribution in materials were discussed, especially the optical method of studying (by aid of the polariscope), the strains in transparent models of the machine or structure. In the majority of cases the simplest and the most direct method is the experimental study of a model, from which are obtained the data required for calculating effects on a full-sized structure; hence the laws of similarity have received close scrutiny. The optical effects for any given load, are independent of the thickness of the material, and depend upon the stress difference, so that color effects are obtained which may be regarded as pictures of shear stress throughout the model. Modern researches on ductile materials like structural steel, indicate that such materials fail at some limiting value of shearing stress, and since the places where these limiting values are reached in the model are visible to the eye, the weak places in the design of a structure can be ascertained, and a faulty design corrected, by purely experimental means.

As applied to boiler design and construction, Professor Coker was of the opinion that ample scope for further inquiry was here afforded; but before more exact knowledge can be gained of the conditions of stress in a complicated riveted joint, it appears necessary to examine thoroughly the simple cases.

"Mr. Scoble and I," said he, "have examined the case of the load applied by one rivet to a plate with various amounts of overlap, and the stresses around the rivet holes have been measured with fair accuracy. The stress at the boundary of a small cylindrical hole in a plate has been found almost three times the stress in the full plate and the effects of holes comparable with the width of the tension member, have also been examined in some detail. In the case of a rivet just filling the hole and exerting no tangential effect at the boundary, there is a lessened tension stress across the minimum section at the boundary hole, accompanied by a marked radial tension. These effects have been recently confirmed in a mathematical discussion by Suyehiro. Other cases give satisfactory agreement with calculations, and we may therefore feel some confidence that experimental investigation will prove useful in some of the very complicated cases arising out of engineering practice, where analysis is difficult if not impossible."

THE BEHAVIOR OF METALS UNDER STRAIN

The same subject was dealt with by Dr. Walter Rosenhain, who stated that for a rational understanding of the behavior of metals under strain, the truly crystalline character of all metals and alloys in their normal (cast or annealed) state, was of fundamental importance. The more detailed and difficult questions connected with the deformation and fracture of metals which have received increasing attention recently, were next considered, including such phenomena as "fatigue," testing by, and failure under, shock or repeated impact, and the phenomena of semi-plasticity and elastic recovery. The behavior of metals at high temperatures was also discussed, and the explanation of these phenomena afforded by the modern development of the theory of an amorphous phase in metals, as originated by Beilby and extended by the author and his collaborators, was summarized.

An interesting paper on "The Economics of Liquid Fuel for Marine Purposes," was read by Professor Kirkaldy, and although this related chiefly to the use of fuel for steamships, some of the points discussed in the paper, cover equally well the supplies of liquid fuel for power purposes, on land. Discussing the advantages of oil as compared with coal for ships, he submitted the following tabulation:

WHERE USED AS FUEL FOR STEAM BOILERS

(1) One ton of oil will do the work of 1½ tons of coal.

(2) The bunker space is greatly reduced because: Less fuel need be carried; the oil can be pumped into any out of the way space in the ship; and oil can be carried in the ballast tanks.

(3) Economy in transporting, handling, storing and stowing.

(4) Less labor is required, because the number of firemen can be reduced by one-third; no trimmers are required; food costs are also reduced by one-third; less accommodation is required for the boiler-room staff. The saving in wages, food and cost of fuel in a recent trial of oil against coal, tried on the same vessel, showed an advantage in favor of oil of $170 in one day's steaming, on a ship of 3800 tons.

WITH INTERNAL-COMBUSTION ENGINES

(1) One ton of oil will do the work of four tons used for heating boilers.

(2) There is considerable reduction of bunker space over oil-fired boilers and steam engines, and a much greater saving of space over coal-fired boilers and steam engines.

(3) There is the economy in handling, transporting, storing and stowing already noted, and less labor is required. Here there is an economy over boilers and steam engines, as neither firemen nor trimmers are required.

(4) The engines occupy much less space than the steam boilers and engines.

As regards the world's resources of liquid fuel, the author stated that these are far greater than were at one time recognized and include oil in the fluid state and various shales, coal, etc., from which oil can be distilled.

As regards oil in the liquid or fluid state of areas already supplying oil, there is eastern Europe, and apparently a vast workable area running thence throughout Asia, to the Pacific. The known resources of North and South America are great, and in Canada, the West Indies and in many parts of South America, there is promise of equally rich supplies yet to be tapped.

The various shale areas have hitherto scarcely been worked. Scotland is rich in shales, and there are rich areas in Australia, New Zealand and South Africa. So far as coal is concerned, to utilize it in this way would result in economizing coal resources, and much that is now wasted would be utilized. Some distilled oil contains impurities, but this drawback must sooner or later be overcome.

DISTRIBUTION OF PHOSPHORUS IN STEEL

A paper by Doctor Rosenhain, of interest to boiler-makers, dealt with the distribution of phosphorus in steel. The author stated that the injurious influence of phosphorus is generally recognized, so much so that for a large class of important steel articles, it is usual to specify that the phosphorus content shall not exceed 0.035 per cent. If phosphorus were uniformly distributed throughout steel, it would be difficult to believe that less than four parts in ten thousand could be seriously injurious. Observations of ordinary commercial steels, however, serve to show that phosphorus is not uniformly distributed. This matter has been studied by J. E. Stead, by the method of heat-tinting, which differentiates between those parts of a polished steel surface rich in phosphorus, and those free from it, by the difference in the rate of oxidation. The banded distribution of the phosphorus thus reproduces as bands of different depths of tinting, on the surface, after exposure to heat.

More recently, the author and J. L. Haughton, at the National Physical Laboratory, worked out a method of tracing the phosphorus distribution in steel, by means of a new reagent. This is a solution of ferric chloride, rendered acid by hydrochloric acid, and containing in solution small quantities of the chlorides of copper and tin. When a steel surface is exposed to this reagent, electro-chemical replacement occurs, a small quantity of iron passes into solution, and a corresponding amount of copper is deposited as a thin film on the surface of the steel. In an ideally pure steel this deposit would be uniform over the entire area of the ferrite

constituent, but in a phosphoric steel the copper film is deposited first on those ferrite regions which are most nearly pure, those regions richest in phosphorus being left unaffected for a long time.

TESTING OF MATERIALS BY MICROPHOTOGRAPHY

In this paper Professor Dalby stated that the practice of showing the structure of metals by means of microphotography has steadily developed during the last few years. He recently applied a photographic method of obtaining a record of the relation between the load and extension of metals, right up to the breaking point. The diagrams taken in this way show clearly the peculiarities of the metals at their yield points, and also the actual load on the specimen, at the moment of fracture.

COMMITTEE REPORTS

Two important reports were presented, one dealing with "Gaseous Explosions" and the other with "Stress Distribution." The former was the seventh report of the scientific committee, which was first appointed in 1907, for the study and investigation of the explosion phenomena in internal-combustion engines. The report presented this year contains a summary of the contents of the previous six reports.

The first part is devoted mainly to the subject of the specific heats of gases at high temperatures. The constant-pressure experiments of Wiedemann, Regnault, Holborn and Henning are analyzed and discussed, and a curve is given showing the energy of CO_2, steam and air, in terms of temperature. The experiments of Dugald Clerk are described, and the results obtained compared with the constant-pressure experiments mentioned. The closed vessel experiments of Mallard, Le Chatelier and Langen are analyzed and the results plotted and discussed.

Dr. Watson's researches on the efficiency of a gasoline engine are included. In these, simultaneous measurements were made of the quantities of air, and gasoline taken into the engine, and of the chemical composition of the exhaust gas. The point brought out was that the ratio of hydrogen to carbon in the exhaust was greater than the ratio of hydrogen to carbon in the gasoline used. Additional evidence of this discrepancy is furnished by some experiments of Professor Hopkinson.

Radiation from gases is next discussed and a brief general history of the subject is given, together with a record of the experiments of Professor Hopkinson and of Professor Callendar. The direct effect of radiation on the efficiency of internal-combustion motors, the amount of radiation from flames, and the molecular theory of radiation from gases, as well as the question of the transparency of flames to their own radiation are reviewed. There is an appendix on the radiation of flames by Professor Callendar, giving some account of experiments made with a Meker burner; a second appendix on the radiation in a gaseous explosion by Professor Hopkinson; and a third appendix which contains abstracts from various papers relating to the application of heat radiation, from luminous flames, to Siemens' regenerating furnaces.

The fifth section of the report continues the discussion of the effect of radiation, and is devoted mainly to the consideration of the factors which determine the heat-flow from the gas to the walls of the cylinder. The remarkable effect of turbulence on the rate of combustion is here mentioned. Particulars of Dugald Clerk's experiments are given, and these definitely establish the fact that but for turbulence the speed at which modern internal-combustion engines are run would be impossible. Professor Hopkinson's experiments, in which a fan was placed inside a closed vessel, and the rates of combustion observed with the fan at rest and in motion, are recorded, and confirm Dr. Clerk's results.

The second report on "Stress Distribution in Engineering Materials" stated that the reports presented at the Birmingham meeting of the Association led the committee to the view that the coördination of the results of various researches was rendered difficult by the diversity of the materials used in the tests. It was therefore thought desirable to obtain complete and systematic data with regard to three definite materials, namely, a mild-steel, a hard-steel, and a steel-alloy. Accordingly a stock of three tons standard steel has been obtained for the committee; this consists of dead mild-steel (carbon 0.12 per cent.), axle-steel (carbon 0.03 per cent.) and nickel-steel.

Some of the steel has already been sent to various members of the committee, and in due course full information will be available with regard to the behavior of the three materials, under a large number of different tests.

Information with regard to the manufacture of the standard steels is given in an appendix.

A number of members of the committee have, during the past year, been engaged in investigating subjects dealt with in last year's reports, but in most cases the experimental work is not yet completed. The subjects under investigation are as follows:

Professor Coker and Mr. Scoble, shear tests; Mr. Cook, tests of the physical constants of the standard steels; Messrs. Cook and Robertson, further work on the strength of thick cylinders; Mr. Fulton, alternating stress at low frequencies; Mr. Guest and Professor Lea, combined stresses; Mr. Mason, repeated combined stresses; Mr. Scoble, repeated combined stresses; Dr. Stanton, repeated shear tests.

American Boiler Manufacturers' Association

The twenty-sixth annual convention of the American Boiler Manufacturers' Association was held at the Waldorf-Astoria Hotel, New York City, Sept. 1 to 4, inclusive. The question of the standardization of steam-boiler specifications received considerable attention, and it is hoped that some progress will be made toward harmonizing the variations existing at present between the laws of the different states.

The opening session took place Tuesday morning at 10 a.m. In the absence of the president, Col. E. D. Meier, Capt. T. M. Rees presided. Addresses of welcome by Hon. Henry Bruere, city chamberlain, and Charles R. Lamb, a director of the Merchants' Association, of New York, were made and responded to by W. H. S. Bateman.

Reports of executive and membership committees and appointment of committees on place of next meeting, nominations and auditing, etc., occupied the meeting Tuesday afternoon, and in the evening a reception and dance was held in the Waldorf Astoria.

Wednesday forenoon and afternoon were given to the reports of the committee on uniform specifications and the committee on uniform boiler laws. Thursday the reports were read of committees on uniform system of cost keeping, place of next meeting, auditing and nominations, and discussion of topical questions took place. The banquet was held in the evening.

On Friday there was the executive meeting in the forenoon as the official ending of the convention, and the afternoon and evening were spent at Coney Island. The complete report of the meeting will appear in the next issue.

Recent Court Decisions

Digested by A. L. H. STREET

Right to Enjoin Flooding of Land—In a recently announced decision the New York Court of Appeals recognizes the principle that, as a matter of strict legal right, an owner of land bordering a stream is entitled to have the natural fall of the stream left uninterfered with by any person who has not legally acquired a right of flowage, but decides that one who buys land, knowing that an apparently worthless part of the property is submerged in the maintenance of a nearby dam, is not entitled to maintain a suit to enjoin the owner of the dam from continuing to flood the lands, especially where the dam has been constructed at great expense and is used in supplying electricity for public and private use. (McCann vs. Chasm Power Co., 105 "Northeastern Reporter," 416.)

Right to Maintain Dam—A right to maintain a dam in a stream to develop power, acquired by long continued use without objection from property owners affected, does not authorize increase of the height of the dam, according to the Iowa Supreme Court's opinion handed down in the case of Iowa Power Co. vs. Hoover, 147 "Northwestern Reporter, 858. In the same case it is decided that legislative grant of permission to maintain a dam does not exempt liability for injury to lands along the stream resulting from maintenance of the dam.

Power Plant at Mouth of Mine

At Floodwood, Ohio, in the Hocking Valley, a power plant is now under erection which is to generate current at the mouth of a mine and distribute it to the surrounding territory. There are about 70 mines i nthis district, all of which are possible customers for the station, and within a radius of 50 miles there are numerous towns of good size which

offer a promising field. Columbus is only 60 miles away, and Cincinnati 150. To run the transmission to either city is a possibility of the future.

The plant is located at the junction of Monday Creek, with the Hocking River on one of the flats between the numerous hills along the river bank. A 1000-acre bituminous coal mine adjoins the plant, and the fuel is to be taken from a side hill at an expense which is estimated at 70c. per ton. The coal is easy to get at, and as it will be removed continuously throughout the year, it is thought that the cost will be less than for coal mined for commercial use. The water supply is abundant and good, as there are no mines farther up the river to instill sulphur and other impurities into the stream.

In building, the unit plan has been adopted. Additions will be added from time to time as conditions warrant. The initial installation consists of three 1800-kw. condensing turbines driving three-phase, alternating-current generators. These machines have already been placed on their foundations, but the water-tube boiler equipment and the coal-handling machinery are not yet on the grounds.

Two or three syndicates have an interest in the development, but at the present writing the operating company has not been incorporated. It is planned to have the plant in operation some time in November.

ENGINEERING AFFAIRS

Public Service—To provide for a committee on public relations, to have charge of those activities which include service to the public other than that rendered directly to individual members and the profession as a whole, the public relations committee of the American Society of Mechanical Engineers announces that public service has been designated by the committee on meetings as the central theme for the annual meeting in December 1914. At the request of the committee, the public relations committee has taken charge of the program for Thursday, Dec. 3, and it will be devoted to papers on municipal engineering and related matters. The session will be opened by John Purroy Mitchel, mayor of the city of New York.

Great Exposition (Grosse Ausstellung) Düsseldorf, Germany, in 1915, with the coöperation of the German Museum, Munich, has been instituted under the auspices of the city of Düsseldorf and the Artists, and is designed to represent what human mind and energy have perfected or inaugurated during the last hundred years. It will show the gradual development of science and industry during this period; foremost of all, however, it will illustrate the present high standard of industry and craft. The juxtaposition of the past and present will give the visitor a clear view of the progress which unwearied toil and far-reaching investigation have brought about. The exhibition which, for the first time, is open to foreign firms is backed by a fund of Mks. 5,000,000 guaranteeing its financial success. Prominent persons of wide experience have given their energies to the service of the udertaking, which will be carried through in the dignified way, traditional to the exhibition town of Düsseldorf.

The ten groups to be represented are Art and Science, House and Home, Industry and Trade, Woman, Army and Navy, Traffic, Sport and Hunting, Agriculture and Horticulture, Legislation and Reform. Group 3 contains the subsections of power, light and mechanical labor, engineering, mining, salt works, iron, metals, the trade in manufactured goods, the textile industry, food and beverages, labor, trade, craft, along with allied industries.

OBITUARY

ALBERT B. FRANKLIN ?

On Saturday morning, Aug. 29, Albert B. Franklin, a well known heating and ventilating engineer, died at his home in Melrose, Mass. He was born in Roxbury, Jan. 28, 1852, the son of Benjamin and Clara (Stowell) Franklin, and descendants from Revolutionary stock.

He prepared for college at the Roxbury Latin school, but owing to illness was unable to enter college. Mr. Franklin entered the employment of J. J. Walworth & Co., of Boston, in 1870 to learn the trade of a steamfitter, and continued with that firm until November, 1878, when he left and went into business for himself.

This firm has carried out contracts for heating and ventilating some of the largest public and business buildings in New England, including the Boston State House, the Melrose High School and other school buildings of Melrose, and the Memorial Hall and Melrose Hospital.

Mr. Franklin was a generous giver of his time and his money, and possessed a vigorous intellect.

He was a member of the Middlesex Club, Congregational Club, the Men's Club of the First Congregational Church, Bethlehem Council, the Royal Arcanum, Knights of Pythias, and Garfield Lodge A. O. U. W.

In 1902 he joined the American Society of Heating and Ventilating Engineers; 1905-1908 he was on board of governors; 1911, second vice-president; 1913, first vice-president, and a member of the Massachusetts Chapter and of the board of governors, 1913-1914.

He was married Sept. 30, 1874, to Helen Frances Jenness, who survives him, together with six children. The business will be continued by Mr. Franklin's sons Laurence and Ralph.

THEODORE GERARD MEIER

Theodore G. Meier, treasurer of the Heine Safety Boiler Co., died on Aug. 16. Mr. Meier was born in Bremen, Germany, Mar. 17, 1836. When he was a year old his parents decided to go to America. His father, Adolphus Meier, selected St. Louis as promising to become a great center of business, and sailed from Bremen to New Orleans, with his little family, in a small brig, which arrived safely after a tempestuous voyage of 113 days. From there a steamboat took them to St. Louis in eleven days. Here T. G. Meier grew up with such schooling as the little town then afforded.

In 1842 and in 1849 the family visited Bremen, where Mr. Meier got the advantage of better schooling during his stay of two years, graduating from the High Schoool of Commerce in 1851. He then attended the St. Louis University as a general student. Later he entered his father's business (hardware and cutlery) as a clerk, and for further practical training, entered the employ of Butler, Keith & Hill, Boston, Mass., for two years, re-entering his father's business, to which meanwhile had been added a small cotton factory. He rose from clerk to partner, and in 1862 took entire charge of the cotton factory. He became an expert in the judging of cotton, and was one of the founders of the St. Louis Cotton Exchange, of which he later became president.

During the Civil War, he joined the 13th Regiment of Missouri, was elected its major and served as such until the close of the war.

On Sept. 7, 1863, he married Miss Hattie E. Basham, Louisville, Ky., by whom he had three children.

His firm, Adolphus Meier & Co., was also engaged in exportation of cotton and of tobacco to Europe. The cotton mill for some years made sufficient profits to double its capacity, but afterward its Eastern competitors were able to get rates from the New England States to the Northwest and Southwestern States so much lower than those from St. Louis to these points that this business suffered severely. There was at that time no Interstate Commerce Commission to regulate rates, and wages were much higher in St. Louis than in Lowell. After a protracted struggle, the cotton factory had to go into bankruptcy. A large shipment of raw cotton exported to London by the firm was burned in Hoboken and the insurance lost on some technicality about Hoboken not being part of the port of New York. Some investments in railroads, coke works, iron works, in which the firm was largely interested, suffered in the depression of 1873, etc., and when the senior Mr. Meier died in 1888, the juniors found the firm hopelessly bankrupt.

T. G. Meier then agreed with his brother, Colonel E. D. Meier, to take up the settling of the affairs of the firm with its creditors if time were given. Such was the confidence reposed by all the creditors in his honesty, capacity and determination, that all made agreements with him out of court, and in the course of 25 years he has accomplished the result.

His tastes were plain, his demands on life modest, and his sense of duty paramount to every other consideration.

For the last twenty-five years he had been vice-president and treasurer of the Heine Safety Boiler Co., of St. Louis, and the phenomenal growth of that company is largely due to his financial ability and careful economy. He was able to give personal attention to his duties until his 78th birthday, but his physician urged him to take a prolonged rest on account of hardening of the arteries. He went to Wequetonsing, Mich., where the climate first seemed to restore him, but he became gradually weaker and passed away Aug. 16.

NEW PUBLICATIONS

Two books have been published dealing with the proceedings of the Fifth National Conservation Congress held in Washington, D. C., last November. One of them treats of water-power subjects exclusively and is an important contribution to constructive literature in this subject. The other book contains the forestry reports and addresses which were conceded to be the most valuable ever presented at a similar meeting in this country. The books may be had for one dollar each through N. C. McLoud, treasurer and recording secretary of the Congress, 1201 Swetland Building, Cleveland, Ohio.

HARPER'S GASOLINE ENGINE BOOK. By A. Hyatt Verrill. Published by Harper & Bros., New York, 1914. Size 5x8 inches; 292 pages, illustrated. Price $1 net.

The extensive use of gasoline engines in automobiles or motor boats by persons having little or no knowledge of their principles of operation, has created a field where this book should have wide circulation. Written in a nontechnical and simple style, the text takes up the fundamentals of the gasoline engine, describes the various types, commenting upon their relative advantages and shortcomings, discusses their care and operation, and enumerates the common troubles and the remedies. The illustrations are well chosen and the author is to be commended for adhering closely to the subject as set forth in the title.

ELECTRIC LIGHT ACCOUNTS. By H. M. Edwards. Published by the McGraw-Hill Book Co., New York, 1914. Size 5x7½ inches; 172 pages; flexible leather. Price, $2 net.

The long experience of the author as auditor of the New York Edison Co. and as an active member of the accounting section of the National Electric Light Association, has particularly fitted him as an authority on the subject of public-utility accounting. The text is grouped under three headings, namely: "Balance Sheet or Indicant Accounts," "Income Accounts," and "Miscellaneous Accounts." The first covers such items as plant investment, current assets, suspense account, liabilities and reserves, and under the second heading are included gross earnings and operating expenses.

The subject is handled logically, and although covering practically all items that any lighting company might be called upon to deal with, the treatment is flexible enough to make it applicable, wholly or in part, to any conditions. The explanations render the text easily understandable, and numerous sample record blanks and cost sheets are included. The author urges compliance and coöperation with public service commissions in the matter of accounts and appears to have followed this throughout the book.

BUSINESS ITEMS

Ingersoll-Rand Co., 11 Broadway, New York City, has recently issued two new catalogs, forms 3024 and 3030, on Ingersoll-Rogler Air Compressors. The former, form 3024, is a complete treatise on the "Ingersoll-Rogler" valve and the latter covers the Class ER-1 type of compressor. Both catalogs are profusely illustrated, showing the details of the machine in section. Copies will be mailed free on request.

The Lincoln Boiler Cleaner Co., Lincoln, Ill., recently received a letter from the St. Joe Ice Co., of Elkhart, Ind., reading as follows: "The two boiler skimmers installed in our plant by the Lincoln Boiler Cleaner Co. have been a great success, removing practically all the scale-forming substances and preventing the deposit of any new matters on the tubes. The skimmers will soon pay for themselves in coal saving and additional steam.

The Yarnall Waring Co., Chestnut Hill., Philadelphia, Penn., has just published a new 88-page treatise on the "Lea" V-Notch Recording Liquid Meter, and anybody interested in this important subject can secure a copy by writing direct to the company. The title of the book is "Log Book of the Power Plant." It is full of interesting and instructive data, is well illustrated and goes into complete details as to how this meter is used for all kinds of liquid measurement, including boiler feed, condenser discharge and industrial liquids of all kinds.

TRADE CATALOGS

Alberger Pump & Condenser Co., 140 Cedar St., New York. Catalog E. Alberger centrifugal pumps, Alberger-Curtis steam turbines. Illustrated, 56 pp., 6x9 in.

The Roto Co., Hartford, Conn. Catalog No. 40. Roto tube cleaners. Illustrated, 6x9 in.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1086. Kerosene engine generating sets. Illustrated, 12 pp., 8x10½ in. Bulletin No. 1087. Polyphase induction motors. Illustrated, 20 pp., 8x10½ in.

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn. Catalog. "The Log Book of the Power Plant." Lea V-notch recording liquid meter. Illustrated, 88 pp., 6x9 in.

National Transit Co., Oil City, Penn. Loose-leaf binder and bulletins Nos. 10 and 11. Pumping machinery. Illustrated.

Murray Iron Works Co., Burlington, Iowa. Pamphlet No. 11. Murray-Corliss engines and alternating-current generators. Illustrated, 12 pp., 9x11 in.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Attleboro Gas & Light Co., Attleboro, Mass., has purchased an 18-acre site and will construct a new plant.

Bids will be received by the Trustees of Public Buildings, Capitol, Albany, N. Y., until 2 p.m., Sept. 10, for heating and ventilating apparatus, plumbing and electric wiring for rooms of the fifth floor of the New York State Capitol. Lewis F. Pilcher is State Arch.

Plans have been prepared for the construction of amunicipal electric-light plant at Bath, N. Y. The estimated cost is $50,00. W. W. Babcock is Chn. of Bldg. Comm.

The Board of Public Utility Commissioners has granted permission to the Riverside Traction Co., Burlington, N. J., to issue bonds for $51,000 for the construction of a new electric power plant.

Bids will be received by the Lighting Committee of the Borough Council, Butler, N. J., until Sept. 14, for constructing a municipal electric-light plant. Runyon & Carey, 845 Broad St., Newark, are the Engrs. George J. Fritz is Borough Clk.

SOUTHERN STATES

The citizens of Rock Mart, Ga., voted to issue bonds for the enlargement and improvement of the municipal electric-light plant.

The State Board, Baton Rouge, La., is having plans prepared by Favrot & Livaudais, New Orleans, for the construction of a new power plant at the State Insane Asylum at Pinesville, La.

Plans are being prepared by W. L. Thompson, Elect. Engr., Boyce, La., for the construction of a municipal electric-light plant at Melville, La. This power plant is to be erected on extensive lines and is to have several sets of high-power machinery.

The municipal electric-light plant of the city of Henderson, Ky., which was recently damaged to the extent of $10,000 by a tornado, will be rebuilt.

CENTRAL STATES

Plans are being prepared for the reconstruction of the municipal power plant at De Graff, Ohio, which was recently destroyed by fire. J. T. Scott is Supt.

The Loveland Light & Water Co., Loveland, Ohio, has been organized with $50,000 capital by Stanley Matthews and associates. The company will take over and reorganize the local electric-light system and water-works.

Plans are being prepared by Frank Van Tuyl, Arch., 1112 Union Trust Bldg., Detroit, Mich., for the construction of a power plant for the Detention Home in Detroit.

Press reports state that the Commonwealth Edison Co. has purchased 21 acres at 100th St. and Ave. N, Chicago, Ill., and will erect a power plant to supply the manufactures with power. William A. Fox, Chicago, is Secy.

WEST OF THE MISSISSIPPI

The plant of the Grundy Center Electric Co., Grundy Center, Iowa, recently damaged by fire to the extent of $10,000. J. B. Calderwood is owner and Mgr.

Press reports state that the municipal electric light, South Stillwater, Minn., was recently destroyed by fire. The estimated loss is $20,000. Paul Pracht is Mgr. and Supt.

The Town Council has granted a 40-year franchise to A. B. and V. B. Johnson, of the Marshall Milling Co., Marshall, Ark., to build and operate an electric-light plant in Marshall.

The State Public Service Commission, Boise, Idaho, has granted permission to Dunkle Bros., Plummer, Idaho, to construct and operate an electric-light plant in Plummer.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance. **Positions Open,** (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale,** 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. p

POSITIONS OPEN

AN A-1 POSITION is open to a good man capable of developing steam specialties and taking charge of manufacturing end of advertiser's business. P. 302, Power.